THE COPPER BRONZE AGE IN INDIA

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An integrated archaeological study of the Copper Bronze
Age in India in the light of chronological, technological
and ecological factors, *ca.* 3000-500 B.C.

by

D. P. AGRAWAL

WITH A FOREWORD BY

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Dedicated
to
My Parents

FOREWORD

DR. D. P. Agrawal has long been known and respected by archaeologists throughout the world for the excellent work of the radiocarbon laboratory of the Tata Institute of Fundamental Research, Bombay. The many C-14 dates determined by his laboratory have provided the basic scientifie time-structure for the pre-and protohistory of India and have made a major contribution to the worldwide efforts to create a seientifically sound chronology.

And now, with the publication of this book, Dr. Agrawal goes far beyond the problem of merely dating individual samples and presents for the first time an integrated study of the archaeological, technological, and chronological evidence for early South Asia. This is a pioneering effort in the history of South Asian archaeological and historical research. His analyses of the chemical composition and manufacturing techniques characteristic of various assemblages of metal artifacts cast fresh light on the basic questions of relationships between different South Asian cultural groups.

As is true of any major pioneering effort, there will be some of Dr. Agrawal's conclusions and interpretations that will be contested by other scholars. But this is a healthy condition for any new science. This is where the real importance of this book comes out. Dr. Agrawal's presentation of thc results of his new technological studies will help us all to clarify the complex pre-and protohistorics picture by delimiting the scientifically verifiable possibilities and probabilities.

It is hoped that this book will help foster a new spirit of archaeological research in India-one that will welcome and utilize the vast technological facilities available in this modern world.

Dr. George F. Dales

FOREWORD

This volume has been long overdue and is welcomed by archaeologists throughout the world for the excellent work of the radiocarbon laboratory of the Tata Institute of Fundamental Research, Bombay. The many date determined by the laboratory have provided the basic scientific underpinnings for the cultural prehistory of India and have made a major contribution to the worldwide efforts to create a scientifically sound chronology.

And now with the publication of this book, Dr. Agrawal goes far beyond the problem of merely dating individual samples and presents for the first time a well-integrated study of the archaeological, technological, and chronological evidence for early South Asia. This is a major contribution to the history of South Asian archaeological and historical research. The analysis of the chemical composition and manufacturing techniques characteristic of various assemblages of metal artifacts can throw light on the whole questions of relationships between different South Asian cultural groups.

As is true of any major pioneering effort, there will be some of Dr. Agrawal's conclusions and interpretations that will be contested by other scholars. But this is a healthy condition in any science and this is where the real importance of this book comes in. Dr. Agrawal's presentation of the technical/chronological studies will help scholars to clarify the current archaeological picture by delineating the scientifically defensible possibilities and explanations.

It is hoped that this book will help foster a new spirit of archaeometallurgical research in India, one that will welcome and utilize the new technological insights available in this modern world.

Dr. George F. Dales

PREFACE

THE PRESENT STUDY is an account of Indian protohistoric archaeology—but with a difference. This book purports to integrate the technological and ecological data within the framework of an absolute chronology—to produce an archaeological reconstruction. General books on archaeology devote considerable space to the details on pottery, typology etc., but technology and ecology are only touched upon as fringe topics. I have compensated this subordination of technological and ecological evidence by giving more importance to them here. When we call an epoch a Copper-Bronze Age, we mean that copper and bronze technology did play a significant role.

I believe that for a meaningful and valid archaeological reconstruction of the prehistoric period, a multi-disciplinary approach is a desideratum. By studying the copper-bronze technology of the protohistoric cultures, in the ecological milieu obtaining them, I have tried to resolve some of the archaeological problems. I have only made a beginning by interpreting the available data, but it is a beginning only and much more work is needed in the directions suggested in the book. The present work is thus also a plea for fostering inter-disciplinary collaboration in India. Research on archaeological-metallurgy on a more ambitious and long-term scale is being undertaken now and in this project I am also actively participating.

For the general reader, pointed summaries and discussions are provided after every technical sub-section; maximum uptodate data has been packed in—at times, forcing the descriptions to become 'telegraphic'—for the benefit of the specialist. To prove the objectivity of the contentions made, the tables and charts form part of the text, and not of the appendix.

I am fortunate enough in getting collaboration from scientists, working in diverse fields, who have contributed to the various facets of the present study. Most of the radiocarbon measurements however were made by me in the Tata Institute of Fundamental Research, where I work.

I owe a debt of gratitude to Prof. D. Lal of the Tata Institute for his invaluable help at every stage of the present work. Sir Mortimer Wheeler of the British Academy, London, and Dr. F. R. Allchin of Cambridge University, U. K.; Ss. B. B. Lal, B. K. Thapar and M. N. Deshpande of the Archaeological Survey of India, and Prof. H. D. Sankalia of the Deccan College, Poona, helped me with many valuable suggestions. Dr. K. K. Sinha, with whom I have an old academic association, greatly helped me shape the work in this form through his incisive criticism. To all these great archaeologists, I am deeply grateful. But for the views expressed here and the errors of omission and commission I alone am responsible.

Thanks are also due to Prof. G. R. Sharma, Drs. J. C. Gupta and P. L. Gupta for giving me the metal samples, and to Dr. K. T. M. Hegde for allowing me to use his valuable data. I am grateful to Ss. D'Silva and K. S. Shivaramkrishna for extending the spectroscopic and metallographic facilities at the Bhabha Atomic Research Centre, Bombay.

My esteemed friends Ss. O. P. Tandon, S. P. Gupta, M. C. Joshi, B. M. Pande, P. S. Negi, K. N. Dikshit and K. R. Dube deserve special thanks for their multifarious help. I am extremely grateful to Mrs. Vibha Tripathi for her valuable assistance. But for the devoted help and collaboration of my most esteemed colleague Km. Sheela Kusumgar, the present study could not have been completed. I am deeply obliged to Km. Statira Guzder for the multiple and significant contributions she has made in the preparation of the book. But for this final stage, I would have liked to include also the ideas I got in the course of stimulating discussions with her. There are so many other friends who have helped me in various ways in producing this work.

To Lata, my wife, I owe a great deal for checking the typescript, and helping me in expediting the work.

I gratefully acknowledge the courtesy of E. J. Brill, Leiden, for allowing me to reproduce Figures 11 and 13 ; of John Baker Publishers, London, for Figure 14; of Routledge and Kegan Paul Ltd., London, for Figure 12; and of the Director General of Archaeology in India for Figures 1, 2, 3 and 19. Figures 21 and 22 have been adapted after the Survey of India atlas maps.

The quality of the get-up and layout of the book owes a great deal to the personal and aesthetic interest of Sri Devendra Jain, of the publishing firm.

July, 1969 D. P. Agrawal
Tata Institute of Fundamental Research
Bombay-5

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CHAPTER 1

INTRODUCTION

In 1956 the late Dr. R. Oppenheimer, the father of the atom bomb, invited some leading physicists and archaeologists at the Institute of Advanced Studies at Princeton, New Jersey, to discuss the possibilities of applying nuclear techniques to the solution of archaeological problems. One of the results was that E. Sayre (and others) applied neutron activation analysis techniques to various archaeological problems with spectacular results. For example, he could establish the manufacturing centre of the Mayan Fine Orange ware at Kixpec (SM 58) and detect ancient forgeries in the Stamped Arretine ware.

Fred Hoyle, the celebrated astronomer, writing a scientific paper on Stonehenge in the pages of *Antiquity* may look queer to many but is only a reflection of the inter-disciplinary nature of archaeological studies today.

Two points emerge from the foregoing instances : (1) the immense potentialities of scientific investigations on archaeological problems ; and (2) the awareness of the scientists of their new role in this field.

In the West, closer and closer collaboration in ever wider fields of archaeological investigation, between the natural scientist and the archaeologist, has led to very important discoveries. In fact, Biek (Bi 63) put the point a bit too strongly when he said, "archaeology has become too important to be left to the archaeologists." In India the magnitude of these potentialities has yet to be realised fully and, then utilized.

Before 1947, much of our archaeology meant palaeography, numismatics and art-history. The discovery of the Indus Civilisation in 1922 was a great event to boost our national pride, but as a cultural phenomenon it remained an isolated event in our prehistory.

The year 1944 was a turning point in Indian archaeology. In the words of Dales (D 66), "The years 1944-1947 represent, perhaps, the most decisive single period in the century old history of archaeology in South Asia. Sir Mortimer Wheeler, one of the most eminent British archaeologists, was appointed Director-

General of Archaeology in undivided India. His brilliant insights into the problems and needs of the tottering Archaeological Survey confirmed and enlarged upon the earlier report by Woolley. Wheeler's masterful tutoring of a cadre of young archaeologists in modern excavation techniques plus his own carefully planned and executed excavations have left a legacy which will endure perhaps as long as some of the monuments themselves."

The post-Independence era saw a scientifically controlled yet prolific excavation activity, mainly concentrated on the protohistoric period. As a result we have accumulated considerable data on the material traits of the Chalcolithic cultures.

Handicapped as we are by the absence of any decipherable script or records, such as would equip a truly protohistoric period, the picture that emerges is still not clear, if not chaotic. To reconstruct this past, typological-morphological studies have not led us obviously very far. In fact, quite often in the maze of morphological categorisations we lose sight of the ultimate end of our enquiries, viz., recapitulation of the past as lived by the people.

In defining my approach in the present work I would like to lay emphasis on the role of technological studies in the background of ecological factors. The reference framework is provided by an absolute chronology. Though primarily this is an archaeological study, yet it is essentially a multipronged—but integrated—endeavour to reconstruct the protohistoric past.

I have chosen the present topic because no such comprehensive and integrated technological study of the Indian Bronze Age has been attempted so far. Also, because I could do more justice to a subject where C^{14} dating and metallurgical studies could yield useful data to resolve the various problems of protohistory. Laboratory facilities for these were available to me in the Tata Institute of Fundamental Research (where I work in the C^{14} Lab.) as also in the Bhabha Atomic Research Centre, both in Bombay.

Importance of a study of the Bronze Age cannot be overemphasised. This represents a turning point in social evolution when man became his own master and could free himself from an abject dependence upon nature. Now man could plan and control his destiny. The advent of Bronze Age in India gave the unique Indus Civilisation—the first town planners of the world!

To elaborate my approach and viewpoint further I would like to quote here extensively from the work done abroad, supplemented with the little work that has been attempted in India in this direction. This will bring into focus the incalculable advantages of inter-disciplinary studies in the field of archaeology. Grahame

Clark (C 63) has compared the archaeologist with a detective : both are trying to reconstruct the past events on the basis of scanty material evidence. And in both cases the help of natural sciences can greatly assist in making the mute evidence speak. The increasing number of physical, chemical and biological techniques that find use in archaeological studies are being described in a growing number of cross-disciplinary books (BH 63; Ai 61a; A 60; Bi 63; Di 68; Ho 65; MNL; PR 65; Py 63).

Any comprehensive archaeological study has to be necessarily based on chronological, technological and ecological factors. Chronological, because without an ordered frame of reference—in terms of absolute time—we will never be able to discern the order in an apparent chaos of data. Technological, because we have to study the artifacts to elicit information on economy, religion, technology, warfare and social organisation, viz., to know how the men lived. Even if the environment does not determine the pattern of human societies, it does provide a challenge of opportunity as well as impose limits. Ecology, therefore, is indispensable in a study of the past societies.

Chronology

Chronology—both relative and absolute—is essential for understanding the pattern of our pre- and proto-history. Archaeological methods have been used for dating antiquities and cultures and quite often with telling accuracy. But more often they need complementing and supplementing by dating based on physical methods. Today, a host of scientific methods is available based on radioactivity, thermoremanent magnetism, thermoluminescence, fission-tracks, the decay and disintegration of various elements, hydration, palynology, soil profiles, dendrochronology, etc. Brill (Bril 61) has been trying to date glass on the basis of the laminations of weathering crusts. Many other methods are at various stages of development (MNL).

A very interesting example is of the Maya Calender correlation. Satterthwaite and Ralph (SR 60) with the help of C^{14} dating have solved this long standing controversy by supporting the Goodman-Thomson-Martinez correlation.

In India the Chalcolithic cultures when first discovered were declared to be very late by many scholars. But now—largely on the basis of C^{14} dating—we have begun to ascertain their temporal extent which is so important for the study of our Dark Ages. For example, C^{14} dates have shown now that there is at least a gap of *ca.* 700 years between the end of the Harappans and the Painted

Grey Ware (henceforward called P.G. Ware) people thus ruling out the claim of the latter as the first wave of Aryans (cf. Chapter 3).

I have myself been engaged in the C^{14} dating of Indian protohistory. The proper use of the C^{14} method requires an understanding of the principles, errors and limitations of the method. These will be discussed in Chapter 3, wherein would be outlined the prehistoric chronological framework based on C^{14} dates as also archaeological evidence. The period covered is *ca.* 3000-500 B.C.

Technology

A sample, collected from Verulamium (U. K.) which formed part of a deposit found on the floor of a building, was scaly and black in colour but clearly not a natural object. On testing, it was found to be iron oxide, but magnetic. It could be shown (Co 63) that these were 'blacksmith's scales', the flakes of oxide forming on red hot iron exposed to the air and falling from the anvil under the hammer. The room was thus shown to be a smithy.

The above example shows how the observations of the archaeologist and the chemist's analyses helped to arrive at a very useful inference. In fact, understanding of the artifacts could never be complete without a full appreciation of technical values. Biek (Bi 63) went so far as to say, "the fundamental validity of archaeology itself, as an independent discipline, is questioned and established, indeed reinterpreted and enhanced, from every point on the perimeter of this scientific collaboration, which in the process benefits everything and everybody else as well."

Many iron tools that have assumed an irregular shape in the course of rusting and weathering can be identified by the non-destructive method of X-ray radiography (Bi 63). In such cases, without X-ray radiography, we could never retrieve the original shape of the artifact. Ore correlations and determination of developmental stages of metallurgy in different areas depend a great deal on spectroscopic, chemical and metallographic analyses. Otto and Witter (OW 52) were pioneers in this type of work. By 1952 they had already done 1500 analyses. A more systematic work was started by Pittioni (P 59), in Austria. By 1959 they had done 1925 analyses. As a result they could show that the hoards of ingots of the Voralpenland were derived from Slovakian ores. They could also correlate the artifacts from the urn fields of the North Tyrol to the deposits of Bertagrube. Oldeberg (O 42-43) could discern the development of metallurgical techniques and the ore sources for Scandinavia mainly through spectroscopic analyses. Recent work in Britain (Ty 62) shows how a number of stages of metallurgy could be determined and important light thrown on the sources.

The analyses quoted above show that for any results to be valid, they have to be statistically sound. In India, too, many workers have analysed artifacts of various kinds but the conclusions arrived at have rarely been statistically valid. Far too many conclusions have been based upon too scanty an evidence; indeed, this has been the rule rather than the exception. The major impediment in obtaining a large number of analyses has been the reluctance of the collectors to provide adequate samples.

However, in my approach, I have tried to follow the statistical method suggested by Friedman *et al* (FC 66). Ore deposit correlations at the present stage of our knowledge may not be very sound, though limited inferences using a statistical method about the nature of the ores (native, oxidised or reduced) can be made. So too can the comparison of spectrographically analysed impurity patterns of ores and artifacts.

Here, in Chapter IV, we will trace the origins and diffusion of metallurgy in a world perspective. In Chapter V will be assessed the data on chemical and spectroscopic analyses to draw conclusions of archaeological importance. In this chapter we have tried to present the available and original data on the analyses of ores and artifacts. Metallographic analyses, the techniques of metal forging, as also functional typology have been discussed in Chapter VI. A detailed treatment of the Copper Hoards' problem will also be found in this chapter.

Talking of the statistical approach, analyses of various industries on this basis can yield important information. In India, Thapar (Th 67) has used such methods to study the microlithic industry of Prakash. Studies with histograms can allow: several sites to be indicated clearly and simultaneously; the percentages of the types of artifacts, the dimensions of the artifacts and their indices to be combined and the percentages to be easily read. Kosambi (Ko 66) successfully used the statistical methods to date the punch-marked coins.

Such studies have yielded highly interesting results (Bo 63). For example, we know that the height of the scraper-edge is an important measurement in the Band-keramik culture; that the size of the scraper-angle can be used to divide Upper Palaeolithic and Epi-Palaeolithic cultures; that the measurement of the graver-angle is generally important in the Palaeolithic; that the breadth of the cutting-edge of a graver is an important measurement in the Perigordian and that the index $\frac{\text{Length} \times 100}{\text{Breadth} \times \text{thickness}}$ gives particularly interesting results when applied to Mesolithic blades.

Pottery studies can be made immensely more meaningful with the help of technical studies. Dark cored wares, for example, generally indicate that the kiln was not used (M 43). With many clays a low firing temperature will not impair the usefulness of the vessel, but it saves a lot of fuel.

Shepard (She 56) has provided much information in her *Ceramics for the Archaeologist* on the basis of which trade relationship in its various aspects between Pecos and the Galisteo basin could be studied. Sayre *etal's* (SM 58) important work on the basis of neutron activation analyses has already been referred to.

Many technical studies, suggested by Shepard (She 56), can very profitably be used to determine the relation between Pre-Harappan and Harappan pottery as also between P. G. and Northern Black Polished (now onwards called N.B.P.) wares.

The petrological examination of neolithic axes (Sh 63) has allowed the complex picture "of axe-making in factories and the discrimination of their products by trade during the Neolithic and Bronze Age" in Britain. Hones made of a fine-grained quartz-mica granulite, imported from Aberdeenshire, were used in Yorkshire.

Sayre (SS 62) has also worked on ancient glass. He has grouped Occidental glasses into 5 groups on the basis of the concentrations of magnesium, potassium, manganese, antimony and lead. He could show on this basis that the glass of II millennium B. C. group wherever found has a high magnesium content. The glass of antimony-rich group was popular during *ca.* 500-400 B. C. in Greece, Asia Minor and Persia. Neutron activation is being extensively used now for various archaeological studies (Ai 61; AA 66; AE 62; HT 65; KE 62).

Price (F 64; FP 65) on the basis of the fission-tracks produced by radiation damage (due to uranium) has been able to date various glasses.

Leeds University has been able to date leather and parchment (Ry 63). This depends on the shrinkage temperature of collagen fibres from the material. In general, older specimens have lower shrinkage temperature. The Dead Sea scrolls were dated by this method.

Very interesting studies of the progressive debasement of gold coins—through electrum—to silver in 7th century coins of Europe have been made by using milliprobe X-ray fluorescent analysis in Oxford (HM 66).

Ecology

In ecological studies—in our attempts to reconstruct the past environment, climate and the biome—the dependence on natural sciences is almost complete. And to understand the past societies a knowledge of their ecology is an imperative. It is the environment that provides the challenge to a society which is answered by it in terms of its technological repertoire. Environment provides both: opportunity and limits.

American archaeologists—Fairservis, Braidwood, Dales and others—are more conscious about the anthropological aspect. They take a comprehensive outlook, conscious of their ultimate aim which is to recapitulate the life as lived by man. The British School, I am afraid, has in the past suffered from a typological obsession—which we too received as a heritage. An example of an ideal team of archaeologists, palaeobotanists, zoologists and other scientists, was the prehistoric investigation of Iraqi Kurdistan (B 60). The fruitful results it led to are well-known.

Geological and geomorphological studies on the lower Indus led Sahni (Sa 56) to think of some physical causes of the decline of the Harappans. Raikes (R 65) has now produced evidence to show several phases of local silting of Mohenjodaro due to impounding of the Indus by tectonic uplifts. Ramaswamy (Ra 68) has also done interesting work on monsoons during the Harappan period.

Subba Rao (Su 58) had significantly remarked, "In a country of the size and environmental diversity of the Indo-Pakistan subcontinent, it is impossible to postulate a uniform development of culture in time and space. The recognition of this fundamental principle—the geographic and ecological basis of Indian history and culture—will help us to understand the true significance of the physical and cultural diversity of the country based on deeper social, economic and technological differences, which are the results of slow penetration of higher cultures in different parts and at different periods."

In India, too, Sankalia, Lal, Thapar and others have utilised the help of botanists in their excavations. Thapar (Th 67) has made use of the analyses of charcoal samples to determine the vegetation obtaining in that period. Cecilia Western (Wes 63) has described the methods and importance of analysing charcoal from excavated sites.

Pollen collections can lead to a fair reconstruction of the plants in the past and thus the past climate (Di 63). Pollen zonation serves as a relative scale of chronology too. For instance, an artifact typologically characteristic of a certain culture may be found associated with the *Landnum* horizon thus equating culture with environment and land use. Mittre and Gulati (BMG 61) have shown the earliest use of lentil, rice, silk, etc. from the Chalcolithic sites. The introduction of new plants and trees can also be detected.

Zoological sciences have a significant and more diverse role to play in eliciting information of great archaeological import. For example, Lal (Lal 54-55) showed, from bone analysis, that the P. G. Ware people were eating pork, venison and beef. This at once showed that the latter day taboo on beef eating did not go beyond 500-600 B.C.

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The domestication of animals has been an important problem. The Zavi Chemi and Shanidar cave faunal remains showed that for the major part of the late Pleistocene wild goats were chiefly hunted. However, coincident with the shift from cave living to an open site, the ratio of goats to sheep changed to 1 to 16 and the percentage of animals under 1 year age increased considerably. The conclusion is obvious : sheep domestication had started (Re 63). It has now been shown that the dog was not the first animal to be domesticated (H 63).

Sometimes we can infer the status of a burial by its faunal remains. For example, the presence of Moa-eggs, used as water bottles, instead of Lagenaria gourds, indicated superiority of rank of the deceased (Ro 56).

A study of total excavated bones from a site can lead to interesting inferences regarding the population size as was done by Clark (C 54). Kubasicwicz (Ku 56) elaborated these studies for medieval Polish settlements. These studies can tell us about population size, duration of settlement, and energy expenditures of a people.

Palaeopathology (Br 63, p. 275) can reveal : the range and antiquity of various diseases in animals other than man; the environment and the precursors of infectious diseases. By Neolithic times, contact between some forms of animal and man had become closer than ever before, and this is a period which is critically important in the transmission of certain diseases to man.

Recent studies (Br 63, p. 328) show that "there is in fact evidence from various groups of various periods that the number of people surviving into adulthood was far more like that found in modern Europe." This shows that the hardships of the earlier less civilised groups were not as severe as was previously imagined.

The fauna indicates climate too. For example, in Hazr Merd (Re 63) the fauna found was similar to today and was not a cold-loving one. On the basis of avi-fauna in Emery-ville it could be established that the shell mound was occupied during winter months (Da 63).

Here, in the present work, we have discussed the ecology of various regions, as it obtained in the protohistoric period, in Chapter VII. We have tried to assess therein the limitations imposed as also the opportunities provided by the different milieu to the various protohistoric cultures.

The instances quoted above substantiate on the one hand the importance of chronological, technological and ecological factors in the reconstruction of the past, on the other, the great and useful role of natural sciences. In these cross-disciplinary ventures the archaeologist stands to gain the most. To ask proper questions from the natural scientists is as important as their answers. We, as archaeologists, therefore have to understand at least the potentialities of a wide range of sciences.

The Late Professor Wiener, a celebrated mathematician, studying the problems of prosthesis had to work with surgeons, neurophysiologists, engineers and neurologists in an integral manner. In this connection he has (We 68) said, "we need a great many different skills. What is not so clear to everyone, but is quite clear to us, is that these skills must be combined to a very considerable extent in the same person." This seems to be a very pertinent remark for the field archaeologist too.

The foregoing examples demonstrate the role that the natural sciences can play in extracting maximum information from the mute artifacts. I do not claim to have used all the methods quoted above, nor is it possible within the means of a single worker. I have however myself carried out a large number of radiocarbon determinations and the statistical analysis of the chemical data.

The present venture is a beginning in the direction of evolving a multipronged, yet integrated, approach to understand the past. Towards this end I have used my own technical data, as of others, to present a coherent picture. Wheeler (W 58) has referred to three stages in any scientific investigation: "The first stage is one of limited knowledge and restricted inference (often wrong). Upon this follows the accumulation of scraps of evidence which tend to constitute an untidy and incoherent heap. Only, later, when this heap has sufficiently grown and matured, does it begin to take an assured place in the landscape."

Dales (D 65) and Lamberg-Karlovesky (L 67) have already started attempts at synthesis, howsoever tentative the conclusions may be at this stage.

I feel it is time we made some conscious attempts to delineate the picture that emerges from this seemingly untidy heap of evidence. The present work does not claim to solve all the outstanding problems; it, of course, does throw out some clues and provide some answers. For example, I have attempted to answer the following types of questions:

What is the role of copper base metal in the Harappa culture, especially in urbanisation ?

What is the direction of diffusion of various material traits, including metallurgy ?

What is the contribution of ecological factors in the spread and extinction of the Harappa culture ?

What is the relation and status of copper-bronze technology of the Chalcolithic cultures *vis-a-vis* Harappans ?

Why did not the Chalcolithic cultures* urbanise ?

What is the role of copper and iron technology in the urbanisation of the Doab ?

To provide a backdrop to these problems a comprehensive, yet concise, survey of the latest results of archaeological explorations and excavations in the Indo-Pak sub-continent has been given in Chapter II. Condensing such a vast mass of data into a meaningful summary in a few pages did prove a difficult task indeed. Still, an attempt has been made to include all the significant details of a cultural assemblage. Marshalling of these data has albeit been a little tendentious so as to highlight the problems that need attention. After each group of cultures have been enumerated the problems that emerge, which, to a certain extent, have been tackled in the present study.

Metallographic and spectroscopic analyses of my samples have been carried out in the Bhabha Atomic Research Centre, Bombay. I have taken the liberty of utilising all the other relevant available data for independent interpretation.

I would have liked to take up a much larger number of analyses. But, despite my best efforts, the procuring of archaeological samples did not prove an easy task.

Finally, I feel that this technological orientation has a more fundamental contribution to make in the present controversy of the Two Cultures. Archaeology in its non-conformist outlook has made "nonsense of two cultures". "For the broad understanding in depth which is of primary importance, archaeology—most human of sciences, most scientific of humanities—provides the only firm common ground." Wheeler (Bi 63) said, "Here is a discipline in which the dichotomy is nearly healed". "It is the enormous unifying potential in archaeology, in a past that is real and live, for bringing together minds caught up with current pattern of diverging humanities and sciences." This then is at once an explanation of the approach used as well as justification of the present work. In Chapter VIII, we have tried to integrate the diverse and multifold data to produce an archaeological reconstruction. If the present multiple, yet integrated, study helps a little to heal up this dichotomy which is at the moment too glaring in India, the author's labours will have been rewarded.

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*The term Chalcolithic cultures, throughout this work, includes the Banas, the Malwa, the Jorwe and the other pre-iron cultures, to the exclusion of the Harappa and Pre-Harappa cultures.

CHAPTER 2

THE PROBLEMS AND THEIR BACKDROP

In the present chapter I propose to survey the protohistoric scene in the light of recent archaeological discoveries. Temporally the span covered is *ca.* 3000-500 B.C. and, in terms of space, the whole of India (Indo-Pak Subcontinent) north of Godavari. This survey is aimed at providing a perspective for the problems that will emerge as also for our endeavour-in the present work—to seek clues towards the solution thereof. This chapter presents the basic data and the different views descriptively—mostly without comments. These data include evidence on metal and chronological links also. The evidence presented here will be utilised and examined in the relevant chapters subsequently. The sites have been described with an ecological bias. The problems that emerge are formulated after sections II, III and IV. We will discuss the evidence under the following categories:

I. Pre-Harappa cultures.
II. Harappa culture.
III. Other Chalcolithic cultures (Banas, Malwa, Jorwe, etc.).
IV. Painted Grey Ware culture and the beginning of Northern Black Polished Ware.

While dealing with the sites, absolute dates have been deliberately avoided. The chronological framework at many places is still blurred and at others matter of serious polemic. Hence we will discuss chronology in detail in Chapter 3. However, cultural-period labels have been used throughout the chapter.

2.I. *Pre-Harappa Cultures*

Our survey starts from the Indo-Iranian border land. This is mostly a hilly area, contiguous with the Himalayas. These mountain ranges separated Indo-Pak subcontinent from the earlier centres of civilisation further west, and served as bridges for transmitting the cultural impulses, though in an attenuated form. Spate (Sp 63) described the region as, "The arid basins and hills of Baluchistan form the eastern portion of the great Iranian plateau, sharply marked off from the Indus plains by the Kirthar and Sulai-

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man ramparts. Looped between Toba Kakar and Sulaiman ranges with trellis-patterned basins of the Zhob and the Beji : nested folds of Cretaceous and Eocene limestones and sandstones producing in Loralai an extraordinary landscape of innumerable scraps and hogsbacks, small plateau and mesas, steep craggy outcrops with talus slopes and set in these arid hills, grey and dun and ochre, a few greener patches in small alluvial and detrital basins."

Oases, in such an environment, must induce isolation. The terrain served as a deterrent to closer contacts and communication. Geography provided an ideal setting for a plethora of disparate tribal cultures (Tri pre). It is in these oases that the first peasant cultures thrived, imbibing much from the Iranian cultures.

AFGHANISTAN

In south Afghanistan, MUNDIGAK, has provided a very interesting sequence (Cas 61). The settlement starts with a handmade pinkish pottery (Period* I_1); shortly after, in Pd I_2, wheel thrown pottery with western affinities appears. Pd I_2 marked the beginning of copper also. In Pd I_3 Amri influences in pottery and architecture and introduction of painted humped bull figurines is discernible. Stone stamp seals with concentric geometric designs first appear in Mundigak II and III. Pd II shows relative isolation from the west and slow growth with additions in copper repertory of eyed needles, daggers with mid rib and tangs, pin with a double volute head. In Pd III suddenly several influences from Iran, Amri and Harappa are evidenced resulting in a variety of pottery and tool types. Copper tin alloying is first attested to in Pd III_6, as also are shafthole axe and adze. Pd IV represents an urban development, as rampart wall, palace and temple ruins of the period have been identified. In Pd IV some generalised similarities with the Scarlet Ware of Susa and some Iranian motifs (cross hatched designs, naturalistic partridges and ibexes, etc.) continue. Again in Pd V we find hand-made pottery with chequered bands. This Pd shows a complete break from the western influences and degeneration both in pottery and metallurgy. Some anachronistic parallels with Indus in Mundigak IV are pottery traps and a sculptured stone malehead (D 65).

Dales (D 65) notes that bichrome and polychrome pottery styles are first found together in Mundigak III, but have distinctly separate geographical distributions in the south. Polychrome decoration—especially the Nal ware—is found in the Baluchistan uplands, whereas bichrome decoration termed Amri ware is more concentrated in the foothills and the areas bordering the Lower Indus Plain. Despite distinct painting styles, many shapes and motifs are common to the two groups. Dales feels that the multicolour tradition comes from the west. "Why the basic tradition split, with part of the population moving down into the Indus valley and the rest moving into the medium altitude zones (elevation 1000-1300 m.) in Baluchistan, is unknown. It did apparently happen, however, with the result that the two branches developed quite different cultural, economic, and social systems. It has been suggested that Nal people became dependent on a combination of farming and animal husbandry while retaining a degree of nomadic mobility, whereas the Amri people became sedentary agriculturists and urban dwellers and thereby contributed more directly to the civilisation-making process in the Indus valley" (D 65). Whether it was a movement of peoples or only traditions cannot be said with certitude.

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*Period will be expressed as Pd henceforwards.

DEH MORASI GHUNDAI, in south central Afghanistan (Dup 63) has been a centre for transmitting the Iranian influences to Baluchistan. Here Pd I is equal to Rana Ghundai I. Only few sherds were there, but no flint tools. In Pd II the pottery has comparison in Quetta and Iran. The Zhob figurines, compartmented seals, shouldered hoe were met with. Pd III has burials also.

BALUCHISTAN

Baluchistan is essentially a mountainous and semi-arid country, falling west of the monsoonal rain-shadow. The climate is more like that of eastern Iran (Chapter 7). The Harappan sites (Duki, Dabar-Kot) of Baluchistan are located in a transitional zone, with ecological ties with the Indus Valley. "There seems to be a tendency for Baluchi protohistoric sites to be confined to upland regions of Baluchistan" (Fa 59).

In Baluchistan area, Fairservis (Fa 56) and deCardi (Dec 59) have recently done extensive explorations. As a result, we have a fairly comprehensive information on these prehistoric Baluch cultures. However, the value of Fairservis's work was impaired due to the outmoded techniques he used (except for Damb Sadaat). "Faced with the difficulty of identifying mud brick buildings, the excavators resorted to a system of digging by 25 cm. levels.

It is therefore difficult to correlate the wide variety of plain and decorated wares found in the Quetta Valley" (Dec 58).

NAL, in Kalat State, was excavated by Hargreaves in 1925 (Ha 29). Walls of houses had stone bases. Masonry was of three types: one, where large quarried stones with straight cleavage were used; two, where big riverborne boulders were employed and; three, where both types were used mixedly. No entrances were detected. In Amri, Casal (Cas 64) too detected such structures, which he thought were used to raise the heights of houses as a protection against predatory animals.

Hargreaves mainly excavated the Necropolis area. Burials of several types were encountered. In the case of fractional burials, bones both of adults and children were interspersed around the vessels. The third type of burial was of complete inhumation without any defined grave.

In Area D (habitational) were irregular chambers, with burnt wooden rafters and blackened walls. Chert blades and cores were completely absent. The beads were made of agate, carnelian, lapis lazuli, shell, paste, limestone and copper. Ram, humped bull and humanlike figures were met with in terracottas.

The Nal pottery is made of a clay which varies from greenish to pinkish hue and is covered with a cream slip; rarely with a dark red slip. Shapes are: bowls with inverted rims; cylindrical pyxidies; squat pots. Black designs were filled with red, yellow, blue and green, of which red alone is a prefiring colour. The designs are in panels. The animal motifs include bulls, tigers, fishes. Sigmas, Ws, comb-patterns, and intersecting circles constitute the geometric motifs. It is interesting to note that habitational Area D pottery was not polychrome. Could it be that only burial pottery was decorated and the daily ware was simple? The controversy of the inter-relationship of the cemetery and the habitation in Nal has been discussed in Chapter 3. Suffice it to say at the moment that Dales (D 65), contrary to Piggot (Pi 50) and Gordon (Go 58), on the basis of Mundigak III parallels, puts the Nal cemetery earlier than the habitation areas (upper levels of Areas D and F).

In Area D, cerrusite (lead carbonate) and leaden slag were recovered, indicating lead smelting. Amongst the copper objects from Nal may be mentioned adze, saw, axe, chisel, dagger, seal. Some of these implements look like hoes.

In KILI GHUL MOHAMMAD I we have a pre-pottery (rather aceramic) culture with bone and stone tools. In Pd II a wheel made, black-on-red pottery appears. Some decorative motifs recall the Halaf style. Copper also is present. In the Pd III the Indus motifs of bull and pipal leaf appear (as also bricks), though the Iranian influence continues.

Dales (D 65) analysing the data given by Fairservis found his methodology wrong, as in Pd II out of total 12 types of the pottery, 10 were wheelmade. Dales recognises in Kili Ghul Mohammad II-III a distinct cultural unit corresponding to his Phase C.

From DAMB SADAAT, in Quetta-Pishin district, a great variety of wares has been distinguished (Fa 56). In Damb Sadaat I we have a number of wheelmade wares: Sirdar Coarse Buff; Kechi Beg Oxidised; Mustafa Temper; Quetta Micaceous; Malik Dark Slip; Kechi Beg; Black-on-Buff Slip; Kechi Beg White-on-Dark Slip; Kechi Beg Polychrome; Quetta Black on surface; Kechi Beg Red Paint, etc. Wali Sand and Gravel Temper wares are handmade. In Damb Sadaat II we get : Mian Ghundai-Buff,-Plain Red,-Buff Slip,-Fine Slip; Malik Dark Slip; Quetta-Black-on-Buff,-Red Brown on Dark Slip; Faiz Mohammad Grey and Quetta Wet Ware. The Sadaat Single Line Ware is confined to Damb Sadaat III.

The terracotta figurines of Zhoblike mother-goddesses (only in Pd III) with aquiline nose and goggle eyes, as also another type (in Pds II and III) with pendulous breasts and legs bent at right angles, are found; also toy house models. Compartmented clay seals, bangles of terracotta, beads of bone, ivory, chalcedony, lapis lazuli, steatite are met with too.

Some lead ore was also found. Few fragments of copper and daggers were reported from Damb Sadaat II and III. Damb Sadaat stone blades are parallel sided and almost uniform in thickness from end to end.

On the basis of the common occurrence of the Kechi Beg wares, Damb Sadaat I has been equated with Kili Ghul Mohammad IV. Amri affinities of Rana Ghundai IIIb to Kechi Beg wares place it with Damb Sadaat I. If the Faiz Mohammad Grey ware is comparable with the Sur Jangal Grey, Damb Sadaat II can be equated with Rana Ghundai III. The hatched bulls, comb pattern, bird figurine at Mehi, Damb Sadaat II and III can be compared with Kulli too. The Harappan affinities of Damb Sadaat II and III are thumbnail incised pottery, perforated vessels, and bird figurines. The Quetta Wet Ware of Pd II was found at Mohenjodaro in the lower levels.

De Cardi (Dec 65) carried out small scale excavations in central Baluchistan, Kalat area. In Surab region (ANJIRA and SIAH DAMB sites) she exposed a five period sequence. In Pd I the material equipment was scanty. A flake blade industry in chert comparable to Sialk I-III and a red slipped pottery is met with. At

Anjira, there is a semi-nomadic settlement comparable to Kili Ghul Mohammad II. The mud brick buildings attest to permanent settlement in Pd II. The cultural assemblage corresponded to Kili Ghul Mohammad II-III and included the red-slipped burnished ware unknown in Baluchistan and the coarse vessels moulded inside basketry frames. Two horns, presumably detached from small bull-terracottas, are unique, as not reported so far from Kili Ghul Mohammad culture. Pd III is transitional, marked by the appearance of new architectural styles and ceramics. In Siah, Pd II, Phase (i), both the basket marked and the Kili Ghul wares were common. Phase (ii) marked the building of massive podium, later destroyed and replaced in Phase (iii) which is marked by the Zari ware and fine cream slipped pottery. Beginning with Stage B, three stages in the devolution of the Togau frieze could be demonstrated stratigraphically through Phases (i to iii). The period can be related to Kili Ghul IV, Damb Sadaat I on the basis of Amri-Kechi Beg wares. Pd IV coincides in part with the Quetta culture occupation of Damb Sadaat II. In Anjira it is marked by expansion and rebuilding. The fine Nal wares were predominantly cream-slipped and were decorated with bichrome or polychrome designs of great variety, in zoomorphic, naturalistic and geometric styles. The Anjira ware was used for heavy vessels. The Anjira ware provides a link with the Kulli Culture as it occurred in the Kulli levels at Shahi Tump with a pottery hut-urn. Pd V deposits are quite eroded, yet one gets the Periano Wet and the Reserved Slip wares and designs of Rana Ghundai IIIc.

No metal objects were found but the presence of whet-stones in Anjira III and IV may indicate use of metal.

In the south-east, we have the EDITH SAHIR Complex in Las Bela district. Structures with boulders laid in tiers and streets are encountered (Fa 64; Bac 63). Curious are the rectangular structures built in receding stages recalling the Ziggurat idea, and the stone 'avenues'. Here too on the basis of pottery two periods have been discerned; the later period showing Harappan influence.

Further west, in BAMPUR, Persian Baluchistan, deCardi (Dec 67) discovered six periods during her excavations. In Pds I and II we get wheelmade pottery, cream-slipped and painted in black or dark brown with a wide range of geometric and zoomorphic motifs. This has Susan affinities. In Pds III and IV we have links with Mundigak IV. There is however no evidence for links with the Kulli culture. Incised steatite (?) pots are current at Bampur from Pds IV-V; a comparable example from Susa was ascribed to Naramsin's period (2291-2255 B.C.). From Pds I to IV there is continuity in the ceramic style. In Pd V a definite break occurs. The pottery is hybrid in character combining elements of the Kulli, Qalat and subsequent Sugha cultures. In Pd VI a firmer local style emerged. On archaeological considerations, deCardi puts Pd I to the middle of 3rd millennium B.C., or a little earlier.

In South Baluchistan, Kolwa region, we have a number of sites of the KULLI culture (Pi 50). Structures of stone rubble and ashlar masonry, flagged pavements, a variety of burial rites, a distinctive pottery, compartmented stone vessels with incised designs, peculiar terracotta female figures and humped bulls are the main traits. Traces of fortification walls in Toji and Mazena Damb, probably of the Kulli culture were also noticed. At least the Mehi cemetery is very rich in copper-bronze artifacts. An outstanding example is a copper mirror with the handle representing a stylised female.

PIRAK DAMB, a mound in the Kachchi plains, Baluchistan, has yielded a bichrome ware which according to Raikes (R 63) has affinities with the Samarran levels (Iraq), Nineveh III and Arpachiyah. "In fact the date for Pirak that emerges from this is so early—around 5000 B.C.—that any direct cultural evolution from Pirak to the known later Chalcolithic wares of Baluchistan is unlikely." Pending the discussion on such a high antiquity of Pirak ware, we would mention here that Dales (D 65) includes it in his Phase D only.

The pottery is marked by : the use of two colours, black and a shade of brown on a cream or buff slip; a distinct preference for diagonal motifs; an intricate lattice work layout with the use of the slip and the second colour; multiple triangles; rectilinear patterns; juxtaposition of entirely different design-panels separated by vertical lines. Much of the plain ware is hand-made. The decorated pottery is made on a slow wheel. All over the damb occur sherds of a heavy, plain grey ware made on wheel. The ware is accompanied by notched blades which are quite distinctive.

This may fall in the general area of bichrome fashion in the foothills and Indus plain region.

The pottery has a pinkish or buff paste with a pale red or whitish slip. The typical painted decoration consists of zones of non-representational motifs between which, in many cases, runs a frieze of naturalistic representations of animals and plants in a single continuous band around the pot. Grotesquely elongated animals (usually humped bulls), a formalised landscape, very big round eyes, stylised goats and many other motifs filling the space (showing a *horror vacui*) are the main motifs. The 'landscape with animals' has affinities with the Scarlet Ware from Susa and Diyala region.

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The stone vessels with basketry and other designs have identical parallels in Mesopotamia. "The cultural and chronological links of Kulli with Harappa are anything but clear but it has always seemed that some significant connections existed." Now the evidence from Abu Dhabi, Persian Gulf (Bib 64) provides the first material link. Dales (D 65) sees in this evidence the Kulli people who were in fact the middlemen in the trade and cultural contacts between the Harappans and Mesopotamia. The burial cairns containing painted pottery with Kulli affiliations is the main evidence.

The Kulli type figurines are the earliest known occurrence of female representations in Southern Baluchistan.

It seems possible that the Kulli culture of South Baluchistan with its important south Iranian and Mesopotamian parallels was a late development out of the basic Nal complex. The areal distributions of Nal (polychrome) and Kulli sites overlap, but there is a definite altitudinal difference in the zones occupied by these two groups. The Nal settlements are found in the medium altitude zone of from 1,000 to 1,300 meters, whereas the Kulli settlements are found in the lower altitude zone, to 700 meters. Many similarities are seen between the Nal and the Amri pottery repertoires, in both shapes and painted designs. This suggested relative time relationship between Nal, Kulli and Amri Culture settlements is partly supported by reports from Nindovari excavations. Here post-cemetery Nal type pottery having the distinctive floral or buckranium 'Sadaat' motif is found in association with typical Kulli pottery. During the first two seasons at Nindowari only one sherd of Nal (and none Amrian) was found (D 65).

RANA GHUNDAI (Ros 46) in Zhob Valley has given a complete sequence (Pi 50). Pd I has no structures. Hand-made unpainted pottery, flint blades without any sheen, bonepoints, eyed needle, marked this period. The animal bones recovered were of *Bos indicus*, *Ovis vignei*, *Equus asinus*, and four teeth of *Equus caballus*. Nomadic, horse-riding herdsmen using the site as camping ground are suggested by the finds in Pd I.

The Pd II is marked by a superbly painted, wheelmade pottery. The paintings of stylised humped bulls and black buck are painted in black-on-buff and have Hissar I affinities. Unlike Kulli, the elongation of animals here is vertical rather than horizontal. Houses with boulder footings were encountered. It is a brief period followed by a sterile deposit. Pd III, however, is a long period, and shows continuity of tradition from the previous period. A curious red-on-red technique comes up. The multiple-lined squares in this two colour style recall Amri, as also the pedestalled feet with vertical lines. In Pd IIIb the carafe like vessels appear. In Pd IIIc a coarsening of paintings and deepening of red colour of background is evident. A burning and violent end mark the close of Pd IIIc. Pds IV and V show complete break from the previous periods. In Pd IV coarse bowls, painted in a tawdry style, appear. In Pd V the painting tradition too disappears, instead, we get a pottery with patterns encrusted on its surface.

Piggot (Pi 50) has ascribed Nal and Sur Jangal to the RG (Rana Ghundai) IIIc. At Nal mud brick houses (from 5′ to 13′ long walls) on boulder foundations and at Moghal Ghundai traces of rampart too are indicated. Periano Ghundai too has been compared with RG IIIc. Though not recovered from Rana Ghundai excavations, clay figurines of women, hooded with a coif, circular eye holes and grim faces, and crude bull figurines possibly are part of RG III assemblage. Flint points and leaf-shaped arrowheads, and alabaster cups also mark this period. Periano Ghundai gave a copper rod and a ring. The cairn burials of cremated bones at Sur Jangal, Periano Ghundai and Moghul Ghundai may belong to RG III, as typical sherds of RG III have been found associated from the surface finds. The Moghal Ghundai cairns, excavated by Stein, gave finds of Sialk B type; but at this site and at Periano Ghundai the cremation burials were found in pots, one at least under the floor of a room and another by a wall, accompanied by ancillary vessels.

SIND AND PANJAB

Coming to Sind, the region of great Indus plains, Casal (Cas 64) in his recent excavations at AMRI has uncovered a fourfold sequence. In Pd IA we get handmade, mostly rimless, pottery with geometric motifs, and also the Togaŭ sherds. Few wheel-thrown pots also. Chert blades and copper scraps are available, but no structures. In Pd IB, mudbrick structures, different motifs, dish-on-stand, bone and chert tools appear. Pd IC represents the peak with four structural levels. Mound B appears to be a worker's quarter. Pd ID, though brief, shows frequent contacts with Baluchistan and Afghanistan. In Pd II (Intermediate) there are two phases. Dales (D 65) sees in this period architectural and ceramic connections with Afghanistan (Mundigak IV). In the early phase, the Amri pottery continues but a few Harappan shapes emerge. In Pd IIB rampart traces, platforms with postholes are traceable. Its end seems to be violent. Pd III is Harappan. Pd IIIC shows

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many innovations in pot shapes and decoration. Pd IIID is Jhukar culture and Pd IV, Jhangar.

Fairservis (Fa 56) says, ". . . . the presence of such elements as the pipal leaf, the willow leaf, the overlapping scales, hatched triangle patterns, the antelope or ibex in panels and the Amri-Nal polychrome style suggests a rather close relationship between the Amri-Nal and Harappan styles." Ghosh (G 65) sees a hint of close genetic relationship in this. However, Casal (Cas 66) stresses the point that the Harappan material appears at Amri already fully developed, thus precluding any direct growth of the Harappan from the Amrian complex. The Harappan civilisation does not derive from the Amrian; it gradually imposes itself upon the Amrian. The "Harappan modes are intrusive at Amri" (Cas 64).

Ghosh (G 52) in his explorations of Sarasvati and Drishadvati (Bikaner area) found a non-Harappan pottery which has now been identified with that of Kalibangan Pd I. Ghosh used the sobriquet 'Sothi' to designate this culture, though it is not widely accepted so far.

KOT DIJI (Kh 65) gave the Pre-Harappan culture (4 to 16 layers), an intermingling level (3A) and, the Harappa culture (1A to 3). A burnt layer separates the Kot Diji and the Harappan level. In the early stages of Kot Diji culture mostly neckless and rimless forms prevail. In the later stages necks develop; painted designs in black and white also appear. The motifs are bands, multiple loop and many lines to begin with, which later on develop into 'fish scale' pattern. Khan (Kh 65) thinks that the Harappan style fish scales may have origins here. The Kot Diji pottery on the whole is fine, thin, of well-levigated clay, wheelmade, with a ground varying from pinkish to red. The bands were done in red, brown, sepia and a warm black over a cream slip. The dish-on-stand is more common in late levels; relatively it's more delicate in Kot Diji. In contrast to the Harappan, the Kot Diji decoration is fresh, fine and delicate; it is never overcrowded. In the later phases geometric motifs were experimented with. Except for the horned deity, no vegetal or animal motifs were used. Khan has observed Kot Diji affinities with the Pre-Harappan pottery of Harappa, early Amri and Bhoot in Bahawalpur region, as also Kalibangan I.

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Khan (Kh 65) asserts, ". . . . the thick black-on-red ware of Harappa culture did not originate in the thin pinkish Kot Diji ware. Except for a few forms and simple decorative motifs. . . there is hardly any important form or pattern common to the pottery of both Harappans and Kot Dijians. . . . The Kot Dijian ware is very light and thin, the Harappan black-on-red is thick and heavy."

Amongst other finds are the blades of notched, micro and serrated variety and laurel-leaf arrowheads. There is a sharp decline in terracottas in Kot Diji levels. A very realistic bull has been found.

Only one bronze (?) bangle is reported.

Ghosh (G 65) has traced some designs of the Sothi (viz. Kalibangan I) pottery in the Kili-Ghul-Mohammad Black-on-Red slip Ware (radiating lines in solid discs), the Kechi-Beg Black-on-Buff Ware, the Quetta Ware, the Jangal Coarse and Painted Ware and Sur Jangal III, also with Mehi-Nundara. The rustication of the lower parts of the vessels is closely allied to the technique of surface treatment of the Quetta Wet Ware. However, these superficial similarities require further detailed study in the total assemblage.

Sankalia (S 67) holds that the Pre-Harappan people were pushed out by the Harappans to Central India and that they gave rise to the Central Indian Chalcolithic cultures. However, the evidence at present is not conclusive to warrant this statement.

RAJASTHAN

The Rajputana desert covers a very big expanse including the Sind, Rajasthan and parts of Panjab and Gujarat. The Aravallis divide Rajasthan obliquely: in the northwest is the Thar desert; in the south-west is the hilly and plateau region. The Harappan and Pre-Harappan sites are in the northern region which was drained by (now dried up) Ghagghar and Saraswati. The southern region is drained by Banas and Mahi rivers. The Banasian sites are distributed on the south eastern region.

KALIBANGAN, an extensive site on the (now dried up) River Ghaggar, has been excavated by Lal and Thapar (IAR 60-61, 61-62, 62-63, 63-64, 64-65, 65-66).

The extensive mound (of Kalibangan I) was fortified by a Pre-Harappan wall. The mud bricks used are of 30 × 20 × 10 cm. When the occupation had reached an average height of 1.60 m. above the natural surface, the mound seems to have been temporarily abandoned, perhaps following a seismic catastrophe as shown by a sandy layer sealing the faulted deposits. The mound however was soon reoccupied, the event synchronising perhaps with the arrival of the Harappans on the site. Thereafter the structural character of the mound changed.

Only a few pieces of copper were found.

The pottery is wheelmade, light, thin in fabric, red to pinkish in colour and painted in black, combined at times with white, over a self-slipped dull surface. The motifs have a great variety: latticed triangles; segments or scallops with filters; moustache like bifold scrolls; concave sided triangles; naturalistic representations of stag, ibex, bull, scorpion, duck, etc.; butter fly motif; the Indus scales; the buckranium; broad bands on the neck. On the basis of fabric and decoration, Thapar has distinguished A to F categories. The Fabric C in surface elaboration simulated the Quetta-Wet Wares. The Fabric D was distinguished by an exclusive incised pattern and its sturdy look.

We would now survey the Harappa Culture sites.

2. II. *Harappa Culture*

The distribution (Fig. 1) of the Harappa culture sites is vast indeed: from Sutkagen Dor to Alamgirpur on the east-west and from Dher Majra to Malwan on the north-south axes. On this basis some scholars have calculated the area of this 'Empire' to 8,40,000 square miles. Whether at one point of time the Harappan expanse was this vast or not is still a moot point about which we will talk later (Chapter 3). But the main spatial spread of the Harappa Culture shows ecological uniformity. The culture thrived in semi-arid soft alluvial plains, with scrub or gallery forests. To enter the Doab it had to cross the northern end of the Aravallis. Ecologically, as we will see later, the Doab was a different unit, and probably was not congenial to the growth of the Harappa culture.

Wheeler (W 62a) has enumerated the following alternative or accumulative requirements of the Harappa culture: (i) Indus seals; (ii) Indus script; (iii) motifs like intersecting circles, scale pattern pipal leaves, rosettes, and peacocks done in the Indus manner; (iv) shapes like goblets with pointed base, cylindrical vessels with multiple perforations, S-profile jars, dish-on-stand (this occurs outside the Indus also) in a thick sturdy red slipped ware; (v) triangular terracotta-cakes; (vi) kidney-shaped inlays of shell or faience; (vii) discoid beads with tubular holes. As we will see in Chapter 6, some metal tool-types also are distinctive of the Harappans. Besides, gridiron plan of streets and houses is evident in the city centres.

It is understood that all the Harappan sites do exhibit the characteristic traits. In descriptions of the main sites, I will, therefore, concentrate on the divergences rather than on the common

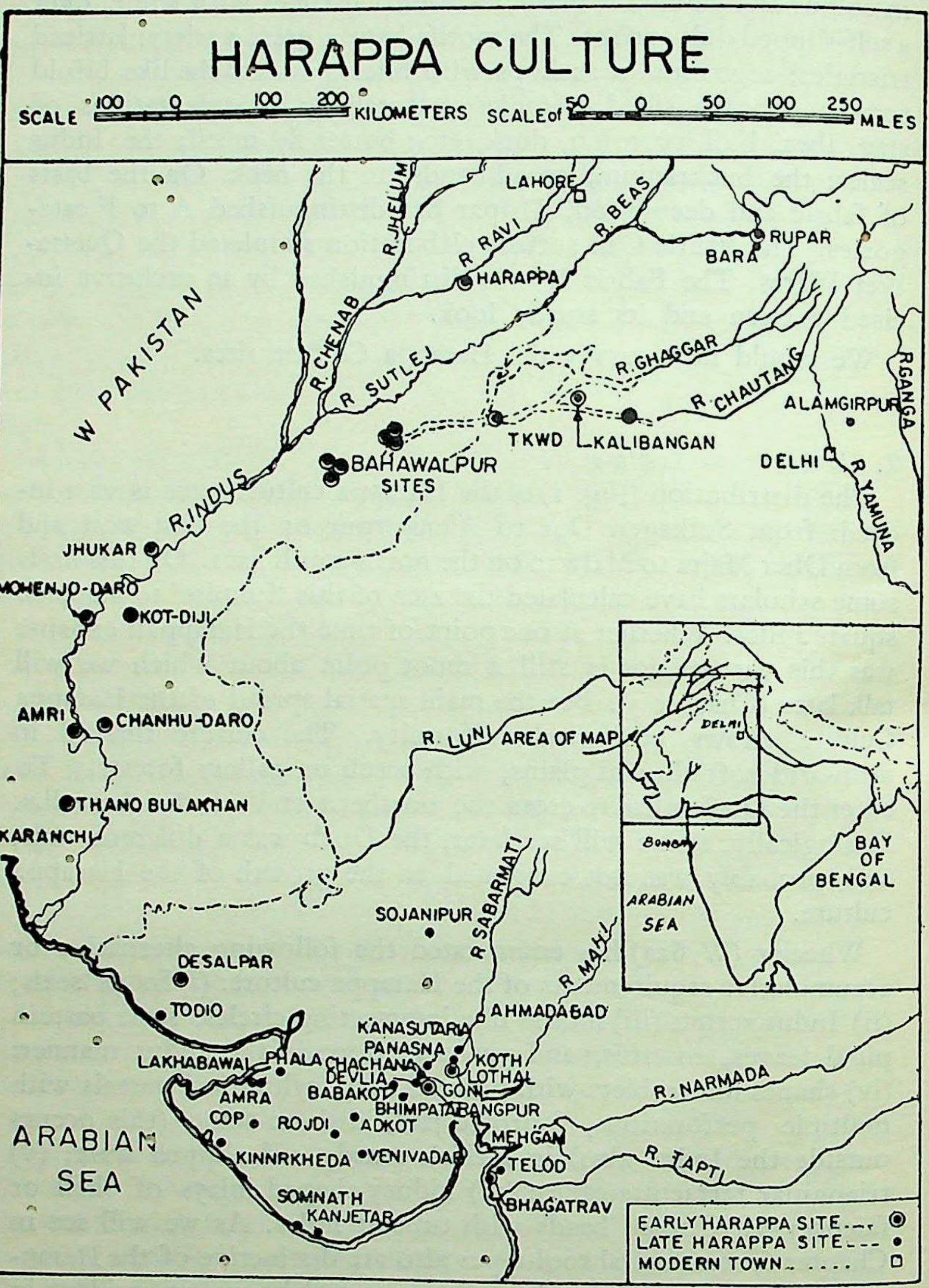
HARAPPA CULTURE
SCALE 100 0 100 200 KILOMETERS
SCALE of 50 0 50 100 250 MILES
LAHORE
R. JHELUM
R. BEAS
R. RAVI
RUPAR
BARA
HARAPPA
R. CHENAB
W PAKISTAN
R. SUTLEJ
R. GHAGGAR
R. CHAUTANG
R. GANGA
ALAMGIRPUR
TKWD
KALIBANGAN
BAHAWALPUR SITES
DELHI
R. YAMUNA
R. INDUS
JHUKAR
MOHENJO-DARO
KOT-DIJI
AMRI
CHANHU-DARO
R. LUNI
AREA OF MAP
DELHI
BOMBAY
ARABIAN SEA
BAY OF BENGAL
THANO BULAKHAN
KARANCHI
R. SABARMATI
SOJANIPUR
R. MAHI
DESALPAR
TODIO
AHMADABAD
KANASUTARIA
PANASNA
LAKHABAWAL
PHALA
CHACHANA
KOTH
DEVLIA
LOTHAL
BABAKOT
GONI
AMRA
R. NARMADA
BHIMPATA
RANGPUR
COP
ROJDI
ADKOT
MEHGAM
ARABIAN SEA
KINNRKHEDA
VENIVADAR
R. TAPTI
TELOD
SOMNATH
KANJETAR
BHAGATRAV
EARLY HARAPPA SITE ◉
LATE HARAPPA SITE ●
MODERN TOWN ☐

Fig. 1. Map showing distribution of Harappa culture sites.

denominators. These points will be useful in discussing the hypothesis proposed later (Chapter 8).

PANJAB AND SIND

Though in the discussion of the Harappa culture the cities dominate, yet it should be borne in mind that for each city there were several villages, which often go un-named. Ghosh (G 52) alone discovered several small sites in Bikaner area.

HARAPPA, the site which gave Harappa culture its name, near Montegomery, in Pakistan, has been excavated very extensively (Va 40). Though "owing to the very thorough depredations of brick-robbers twelve seasons work at Harappa have in the aggregate yielded disappointing results."

At the citadel mound AB, from pre-defence levels, a 20″ deep habitational deposit yielded Rana Ghundai IIIc type sherds.

The citadel is in the form of a parallelogram in plan, 460× 215 yards. The inner buildings were built on a mud and mud-brick platform, 20′-25′ above the ground level, contained on all sides by the massive defences. These defences too had bastions or salients and, later on, buttresses also. Gateways in the north and west are indicated. The residential buildings on the platform however did not yield any intelligible plans.

The mound F has yielded the two 'coolie lines' and seventeen burnt-brick made pounding platforms with remains of burnt wheat.

The most important is the granary complex, each 50′×20′, in two rows of six, with a 23′ wide central passage, and an elaborate air-duct arrangement. Very big granaries have been reported (in texts) from Egypt and Mesopotamia, though their archaeological remains are difficult to identify. "But there is at present no granary in the pre-classical world comparable in specialisation of design and in monumental dignity to the examples of the two Indus cities" (W 62a). The whole complex of granaries, pounding platforms and 'coolie lines', within the shadow of the citadel, betrays its importance in the state machinery, besides reflecting a sort of regimentation.

The 'R-37' cemetery has been regarded as late Harappan, belonging to the common citizens. Its graves show extended inhumation with ordinary funerary goods, heads pointing north. Two graves bear mention: one for its mud brick lined pit; and, the other, for a wooden coffin recalling Mesopotamian practice. A mass of 20 complete and fragmentary skulls with some long bones were found in G area, the significance of which is not clear.

The copper tool types are common to Mohenjodaro and will be discussed in detail in Chapter 6.

MOHENJODARO, in Sind, too is built upon an artificial mound like Harappa. Here too there is a citadel mound and a lower city. The deep diggings of 1950 showed that in the cultural sequence there was no break. The citadel platform was protected by a bund of mudbricks 43′ wide and a large burnt-brick drain ran along the foot of the platform. All this shows that flooding was a problem right from the beginning. It was defended by bastions throughout its circuit, but the defences are of a less simple and uniform kind than at Harappa.

In 1950, the podium of the granary, 150′×75′, was discovered. The granary was built before the Great Bath. A long building 230′×78′ to the north-east of the granary has been presumed to be that of the high priest.

In short, there are many sizable structures like the Granary, the Great Bath, the 'College building', the 'Assembly-Hall', the Peripheral towers, the Citadel which seem to present an aspect of combined religious and secular administration of the Indus civilisation.

The lower city too has some traces of fortification. The layout is in gridiron with 6-7 blocks divided by main streets. One cannot say if the citadel was at the centre of the city. The houses open into the lanes and not the main streets. The houses had courtyards, wells, bathroom, privy, drainage-pipes, and possibly an upper storey.

In the DK area, a big structure 250′ long, was taken to be the palace (M 37-38). Nearby, circular mud-lined pits built of wedge-shaped bricks showed vitrification though the purpose (metallurgical ?) was not clear.

A big building in VR area (87′×64.5′) with neatly paved floors and a room with five conical pits has been suggested to be a restaurant.

A more significant structure seems to be the so-called House A1, in HR area. It is 52′×40′ with 4′ thick walls. Nearby was found the famous seated image of a bearded man. Wheeler is inclined to identify it with a temple and pleads for re-excavation of the site.

The streets were unpaved, but were very well drained with burnt-brick structures. At intervals were manholes which possibly were cleaned regularly by the municipal staff.

We saw the many precautions taken against floods in constructing the citadel complex. In DK area too at least three devastating floods have left their traces. Towards the later phases the degeneration is very much in evidence.

There were no regular burials spotted at Mohenjodaro. However, urns found with 'odds and ends' sometimes mixed with charcoal and ash have been associated with cremations. At Kalibangan (below) too, urns have been found with probable funerary association; but there, unlike Mohenjodaro, they occur in cemetery area.

The copper and bronze objects include spears, knives, short swords, arrowheads, and axes, razors, pots and pans.

'Shoe-lasts', like stone celts, have been used, though are not numerous. The purpose could be agricultural; so also of the multitude of the chert blades. Stone drills and maceheads are the other stone artifacts.

The shipping is attested to by a craft, with sharply upturned bow and stern of a unique type, shown in a seal and a potsherd graffito from Mohenjodaro (M 37-38). Possibly camel, ass and also horse were used for transport. Domestication of elephant is more conjectural. Domestic animals include humped cattle, pigs (?), dog and cat. The toycarts with solid wheels indicate use of ox-cart. Chanhudaro has yielded models of 4-wheeled carts.

The weights show a binary ratio in the lower scale (1, 2, 1/3× 8, 8, 16, 32,. . . . to 12,800) comparable to traditional 16:1 ratio of a rupee; higher weights were decimal with fractional weight in 1/3rds. Possibly the foot was of 13.2″, with a decimal division. A bronze rod with 0.367″ divisions may point to the use of 'cubit' system also.

Wheat (*Triticum compactum* and *Triticum sphaerococcum*) and barley (*Hordeum vulgare*) have been reported. For grinding, saddle-querns were used. Charred peas, melon seeds, sesamum, date stones are indicated; cotton cloth and bast fibre too were known.

At KOT DIJI, Khan (Kh 65) has distinguished an early Harappan level where painted decoration is still uncommon. In this level the designs consist of crude painted peacock, antelope, 'fish scale' and linked balls. The red slip is fugitive.

From the Harappan levels were reported bronze (?) objects: blade-axe (flat), arrowheads, chisels, double and single bangles, and finger-rings. No detailed descriptions are available in the report.

RUPAR (a site on the Sutlej) marks the northern boundary of the Harappa culture. The site is on the junction of the Himalayan foothills and the plains. River pebbles, Kankar stones, baked and unbaked bricks were used. The pottery shows variations. The goblet is rare and in the upper levels completely absent.

The cemetery (IAR 54-55; Sha 55-56) was 160′ away from the habitation and was much disturbed by later pits. Grave pits were about 8′ × 3′ × 2′ with extended burials, head pointing north-west. Most burials had many pots. But in one case the pots were arranged first and then covered with earth, the body was laid last (cf. Kalibangan). The number of pots varied from 2 to 26 and may indicate the status of the individual buried. No mother-goddess figurines were found. The single steatite seal found is unique as it does not have any boss on the reverse.

ALAMGIRPUR, in Distt. Meerut, on the Hindon (a tributary of Yamuna) is very important from the point of view of distribution of the Harappa culture. The finds are of the usual Harappan vintage. Platters, bear and snake (in terracotta) are important finds.

RAJASTHAN

KALIBANGAN, the well-known Harappan site, on the dried up river bed of Ghaggar, has been excavated by Lal and Thapar (*IAR* 60-61, 61-62, 62-63, 64-65, 65-66). Here too there are twin mounds. The Pre-Harappan and Harappan occupations are traceable in both the mounds. The Harappans have, in fact, used the Pre-Harappan wall to raise their fortifications. The Harappan fortification wall has salients, buttresses and entrances on the south and the north. Unlike Harappa, at no place was the fortification wall integral with any of the platforms within the citadel.

The four north-south and one east-west thoroughfares have a fender post at the crossing. The width of the streets and thoroughfares ranged between 1.8 and 7.2 m. and significantly enough approximated to the unit of about 1.8 m. No street has drains. The troughs encroach on the streets.

In the terracottas we have peculiar bulls with elongated body and block legs. A terracotta male head closely recalls the Mohenjodaro specimen. So also the charging bull.

"A noteworthy feature of the houses was the occurrence of oval or rectangular 'fireplaces' at different levels. Whereas the exact function of these structures still remains unresolved, some of the recurrent features were as follows : A shallow pit, oval or rectangular on plan, was first excavated. In this pit fire was made and in the centre a cylindrical (sundried or pre-fired) or rectangular block was fixed. Terracotta cakes seem to have been used in the performance of the ritual" (IAR 62-63). Fire altar like structures were encountered in practically each house. This recalls Lothal fire-altars.

Pottery shows an overlap between the Pre-Harappan and the Harappan wares at both the mounds.

A cylinder seal is also remarkable.

The burials show three practices: (i) extended inhumations with funerary pots and pans; (ii) circular pit burials with urn pots and other smaller pots without any skeletal remains and; (iii) rectangular pits with funerary pots but no skeletal remains. The last type showed that there was a time lag between the laying of pots in the grave and the final filling. A burial, probably of a rich person, shows mudbrick-lined grave, with 70 pots; skeleton lying supine with head towards north.

The basis of these three types of burials is not clear. In one case, a pot burial pit cut into a rectangular grave.

The domestic refuse and animal remains lay on the floor. The important faunal finds are: domestic humped cattle (largest percentage); buffalo; elephant; camel; goat; ass; chital; fowl; turtle; rhinoceros; large number of mollusc shells.

The refuse and animal remains littering on the streets, the drains opening into them, and the absence of any street drainage at Kalibangan may indicate a degeneration of civic standards, and of the society.

It will be pertinent to recall here the similarities and dissimilarities between the Pre-Harappan and the Harappan assemblages. Both the cultures share motifs like fish-scale, pipal-leaf, external cord-impression including graffito marks, shapes like dish-on-stands, ring-stands and lids, bulls and carts, bangles in terracottas and shell, steatite disc beads, quern stones, the knowledge of metallurgy, the 'English bond' in masonry, the fortified township. The dissimilarities are in the brick-sizes, lack of inscribed seals in Pd I, orientation of houses, range of ceramics, the size and material of blades.

The writing is the hallmark of civilised society and it appeared only when the urbanised Harappa culture emerged on the scene. Here, as elsewhere, the Harappans appear with a number of innovations and do not show any traces of slow evolution from the Pre-Harappan culture.

The brief reports so far available do not give details of the copper bronze industry.

SAURASHTRA

LOTHAL, a Harappan city on the Saurashtra Peninsula, was excavated by Rao (*IAR* 54-55, 55-56, 56-57, 57-58, 58-59, 59-60).

The site is set in a 'dead flat alluvial marshy low-land'. Originally the site must have been on the confluence of the rivers Bhogavo and Sabarmati. However, this proximity to the rivers nearing the estuary brought repeated and then final destruction of the habitation. Sankalia (S 62-63) feels that Lothal was very near the sea in its heyday. The site shows two periods: Pd I, mature Harappan and; Pd II, late Harappan. The Black-&-Red Ware* appears in Pd I itself.

The town was divided into six blocks, each built on extensive mud-brick platforms of a varying height and connected with each other by streets 12′ to 20′ wide. Some of the houses had verandahs in front, while others had court-yards. A big house, with elaborate drainage and a separate wall, overlooked the dockyard. A trapezodial brick structure with an overall measurement 710′×124′ with inlet and outlet channels is the most important structure, identified as a dockyard. The structures of burnt-brick, 4′×4′, with terracotta cakes, balls, and burnt earth, sometimes along with a big painted jar, point to their ritualistic nature. A spoon with smoke marks on both the sides is important in this connection. "A substructure of mudbrick, consisting of 12 blocks, each 12′ square and separated by channels of air-ducts 3½′ wide, is probably the base of a granary like that on the citadel of Mohenjodaro. The superstructure had presumably been of timber, it had been burnt. Twisted and burnt clay sealings of normal Indus type had fallen from the stored bales into the ducts" (W 62a).

A steatite seal with an embossed back and a pair of gazelles on the obverse has been reported from Lothal as a surface find by Rao (Rao 63). Comparable seals have been reported from Failaka, near Kuwait, Barbar and Ras-al-Qala (Gl 60). These seals, now known as the Persian Gulf Seals, are circular, unlike square ones of Harappa and cylinders of Mesopotamia. Some 17 examples of such seals were discovered in Mesopotamia. Several of them bear the Indus script. Obviously these belonged to the traders of Bahrain who were the middlemen between Mesopotamia and the Indus.

Contacts between Mesopotamia and the Indus are well-known and will be discussed in Chapter 3. Recent excavations in Turkmenia have brought to light evidence of Harappan contact, in Namazga Pds V and VI. Altin Depe excavations have produced evidence of the Harappan affinity in pottery shapes, beads, metal tools, chert blades, terracottas and even the composite animal of the Harappan seals. Most of these contacts are tentatively dated to post 2000 B.C. period. This shows that the Harappans had contacts with the western and central Asian countries through land route too (GS 66-68).

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*Henceforward referred to as B-&-R Ware.

A shell object has been identified with a 'cross staff' for measuring angles of 180°, 90°, 45°. A graduated ivory scale with 1.7 mm. divisions each was also recovered; so were the plumb bobs.

The copper-bronze repertoire includes a mirror, needle, fish-hooks, chisels, drill-bit, fragment of a fine saw.

The evidence of carts, boats, horses, etc. is attested to by the terracotta models.

After this brief survey, we would note below the salient points and formulate the problems which we propose to tackle against this backdrop.

PROBLEMS AND DISCUSSION

For the north-west India Dales (D 65) has distinguished various phases (from A to F) on the basis of total assemblages. Admittedly the evidence is not clear and the picture is still hazy. But we can see in the whole area (Mundigak, Kot Diji, etc.) that a transition from the village life to fortified settlement was taking place. At Mundigak there was a 'palace' and 'temple' in Pd IV. The potter's marks appear which (Mundigak IV and Damb Sadaat II) may indicate the beginning of writing. A sudden proliferation of the painted humped bulls in Quetta sites, the post-cemetery levels at Nal, the Intermediate Pd at Amri, the Pre-Harappan levels of Kot Diji, may signify the recognition of the role of cattle power in the economy—both in agriculture and transport. The multicoloured painted pottery traditions (of Dale's Phase D) were giving way to the black-on-red pottery all over from Afghanistan to the Indus. Now the stamp seals are also being made of copper indicating relative abundance of metal. The now ubiquitous incised and stone gray ware vessels in south Baluchistan, in Persian Gulf (Umm-an-Nar), and in the various sites of south Mesopotamia reflect growing trade and contacts. All the material evidence thus shows that the area is on the threshold of urbanisation.

In the survey of the north-west we noted that the polychrome tradition becomes confined to the uplands with the people practising a combination of farming and animal husbandry, but still retaining a nomadic mobility whereas the bichrome tradition was concentrated more in the foothills and the areas adjoining the Indus plain e. g. Amri. These people became sedentary agriculturists and contributed towards the process of urbanisation. So here again we see the ecology providing the opportunities as also the challenge for progress towards urbanism (cf. Chapter 7).

Ghosh (G 65) says, "The occurrence of the Sothi ware, comparable in some details not only with the Zhob (Periano Ghundai) but with Quetta and Central Baluch industries, in the lowest levels at Harappa and Mohenjodaro, in abundance on practically all Harappa sites on the Saraswati, the persistence of its traits in the Harappan pottery not only in the Saraswati region but also at Mohenjodaro and Harappa, the co-existence of the Sothi and the Harappan people at Kalibangan (KLB-2) and possibly also at Kot-Diji all this cannot be dismissed as accidental, but, on the contrary, must have a bearing on the Harappan genesis. A firm Sothi substratum is obvious in the make-up of the Harappa, much firmer than that of the other earlier cultures. There is every justification for regarding the Sothi as proto-Harappan". While discussing the Harappan remains of Kalibangan we noted the traits that may have originated in the Pre-Harappa culture.

Dales (D 65) on the other hand notices that "although what may be described as proto-Harappan elements are present at many of the sites from Afghanistan to the Indus valley, one still gets the impression that at stratigraphically excavated sites such as Amri and Kot Diji the mature Harappan imposes itself on the long-established Pre-Harappan settlements."

As we noted earlier, Khan (Kh 65) also asserts that "there is hardly any form or pattern common to the pottery, of both Harappans and Kot Dijians". Ghosh (G 65) too asks "Who was the mature Harappan and where did he attain maturity ?"

Sinha (Si pre) tries to explain the sudden innovations in the Harappa culture on the basis of the far-reaching changes that might have been ushered in the wake of the transition from village to city life. "Changes in pottery style, increased tempo of metal working, presence of architectural forms quite different from the previous ones and employing newer material, diversification of arts and crafts will be normal". I would add that the standardisation in arts and crafts was a natural concomitant of the Harappan city life.

Socio-economically viewing the situation, the developments in metallurgy, the improvement in agriculture, the harnessing of cattle and wind power, the trade contributing to the prosperity as well as to cultural uniformity, was bringing the whole area from Afghanistan to the Indus on the threshold of civilisation. But why did it flower in the Indus alone ?

The aforementioned survey has brought out the following problems into sharp relief:

(i) What is the role of copper-base metal in the Harappa culture ?

(ii) How abundant is it in comparison to the Pre-Harappan metal ?

(iii) What is the reason for the metal abundance and its role in urbanisation ?

(iv) What was the contribution of ecological factors ? Why the cities came up in the plains and never in the hilly country ?

(v) What is the role of chert in the Harappan economy ?

(vi) How do we explain the multiplicity of the cultures of the Indo-Iranian border land and in contrast the uniformity of the Harappa culture ?

(vii) In the chronological framework what are the respective positions of various protohistoric cultures of the north-west and what is the direction of diffusion of various material traits including metallurgy in this region ?

In the following chapters we would present, collate and analyse various data to seek clues towards the solution of the aforementioned problems.

2. III. *Other Chalcolithic Cultures*

Passing on to the other Chalcolithic cultures, we have mostly to depend upon the short reports published in *Indian Archaeology —a Review*. This imposes severe limitations on any attempts at comparative study. Especially, the details about the metal and other industries are difficult to find. I have tried to supplement the data by personal communications, wherever I could secure a response. The principal Chalcolithic sites are depicted on the map (Fig. 2).

SOUTH RAJASTHAN

The south-eastern parts of Rajasthan, though part of the great Rajputana Desert, are fertile and are sheltered by the Aravallis. This area seems to have been subjected to climatic changes in the past, the influence of which we will discuss in Chapter 7. Most of the explored B-&-R Ware sites are confined to this region, which is drained by Banas and its affluents (*IAR* 57-58, 58-59).

AHAR and GILUND, on the river Banas, near Udaipur, have yielded extensive evidence of a Chalcolithic culture, called the Banasian (*IAR* 54-55, 55-56, 59-60).

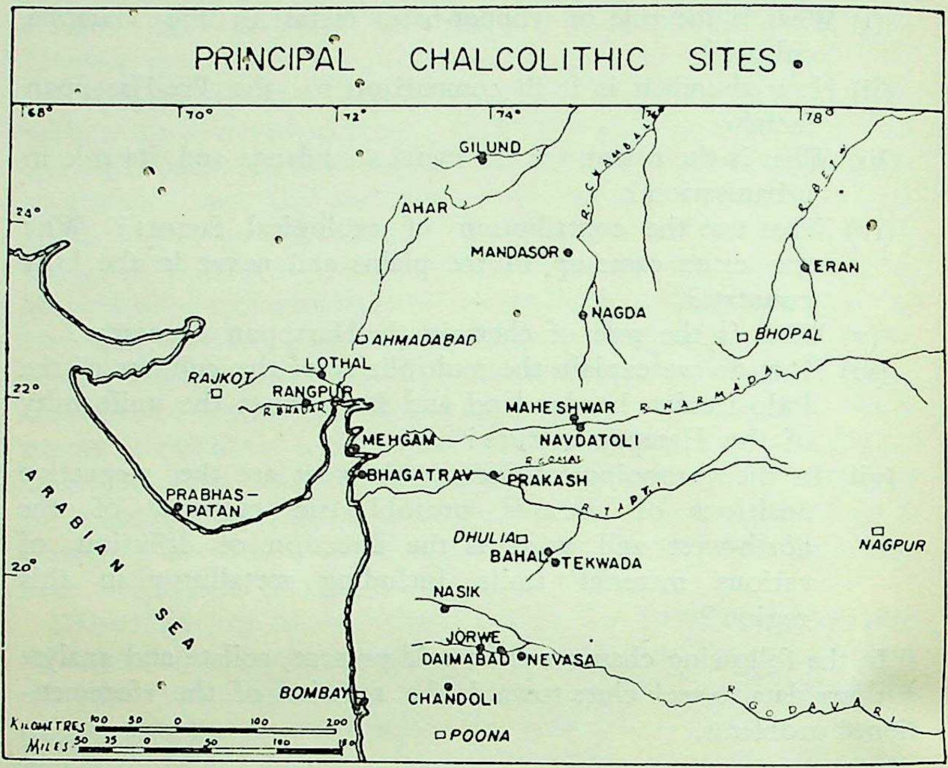
PRINCIPAL CHALCOLITHIC SITES
68°
70°
72°
74°
76°
78°
24°
22°
20°
GILUND
R. CHAMBAL
R. BETWA
AHAR
MANDASOR
ERAN
NAGDA
AHMADABAD
BHOPAL
LOTHAL
RAJKOT
RANGPUR
R. BHADAR
MAHESHWAR
R. NARMADA
MEHGAM
NAVDATOLI
BHAGATRAV
PRAKASH
R. TAPTI
PRABHAS-PATAN
ARABIAN SEA
DHULIA
BAHAL
TEKWADA
NAGPUR
NASIK
JORWE
DAIMABAD
NEVASA
R. GODAVARI
BOMBAY
CHANDOLI
POONA
KILOMETRES 100 50 0 100 200
MILES 50 25 0 50 100 150

Fig. 2. Distribution of the Chalcolithic sites of Banas, Malwa and Jorwe Cultures.

At Ahar stone-and-mud houses were found, the foundation walls of which were built with schist stone. The mud plaster was decorated with quartz nodules. Some of the houses were quite large, e.g. 30′×15′. At Gilund much bigger structures are found e.g. an enigmatic structure of 100′×80′, a kiln-burnt brick wall over a rubble foundation was exposed to 36′. The use of burnt bricks outside the Harappan culture is very suggestive indeed. Bricks are of 14″×6″×5″ size. Some of the ovens are quite big and in one house there were 6 ovens (*chulahs*) in a row.

The copper artifacts included four flat celts, bangles, sheets, etc.

At Ahar, Pd Ia was marked by the buff ware and the cream slipped ware. In Ib, the 'stone-ware' with dish-on-stand and dishes continues. In Ic, the B-&-R Ware bowls develop a marked carination at the shoulder, but the 'stone ware' is absent. The painted B-&-R Ware was the 'table ware'. The storage vessels were of red ware, with the lower portions left rusticated. We have here painted black, plain, burnished grey, red and a few polychrome ware sherds too. The black-on-cream and the B-&-R Wares at

Gilund were found from the upper levels and the rest from the lower levels. In fact, the Navdatoli type of cream slipped ware with designs like dancing figures, etc., has been found in the upper levels of Gilund, whereas it occurs at the lowest levels of Navdatoli. Sankalia (S 63) thinks that the 'stone ware' like fabric is an import. The thin buff and cream slipped wares painted in crimson blackish-red have also been regarded as imports, with affinities in Amri and Nal.

The spindle whorls or beads of terracotta (S 63) have remarkably close resemblance with Troy specimens. Ahar yielded 38 incised spindle whorls, whereas no other Chalcolithic or early historic site has yielded (except for a rough Chanhudaro specimen) any incised examples so far. At Nagda (Pd I) the incised terracotta beads and spindle whorls also look alike, though there is no identity in designs. Also found were the "Bulls with prominent long horns and gamesmen with a variety of heads—one having that of a ram—are after the Indus or Harappa tradition" (S 63).

Both Agrawal (*IAR* 54-55) and Lal (*IAR* 59-60) had reported an insignificant microlithic industry. Sankalia, however, emphatically called this culture as the Copper Age Culture, in contradistinction to the Chalcolithic, because of the complete absence of microliths. The absence of stone tools, viz. blade industry, makes the Banasian culture stand apart from the other Chalcolithic cultures.

Explorations (*IAR* 56-57) brought to light many other B-&-R Ware sites in the districts of Chitorgarh, Udaipur and Mandsor.

SAURASHTRA

RANGPUR (Rao 62-63) is about 30 miles south-west of Lothal, on the river Bhadar, on the immediate plains below the foothills. This coastal strip is quite fertile due to the river Bhadar. Vicinity of the sea and the indented coast facilitated anchorage and hence probably encouraged maritime trade.

Pd I is microlithic without pottery and is dated to *ca.* 3000 B.C. by the excavator.

Pd II is divided into A, B and C phases. Pd IIA is mature Harappan. Beaker and goblets are lesser known in this period. The micaceous red-on-black ware (bowl with a handle), chocolate-on-buff, and coarse grey wares are the new elements.

The buff ware at Rangpur is not similar to the Amri Buff Ware, the latter is fine and thin. The Rangpur buff ware is due to the use of calcareous clay which does not oxidise red, as is the case with ferruginous clays. Mujumdar (Muj 68) too has found the Banasian cream ware to be due to the use of kaolin. Chemical analysis has thus identified a common trait between Rangpur and Banas.

Possibly due to flood the settlement had to be shifted to a new site. This phase is Pd IIB. The convex sided bowls show change; beaker and goblet disappear; small jar and basin are less popular; a bowl with straight sides also comes into use. The decay is evident from the poor structures, lack of ornaments, stone weights and chert blades. No mud-brick houses, drains and baths are to be met with.

Pd IIC shows a revival: the development of the Lustrous Red Ware*; the profusion in paintings of pottery; the popularity of B-&-R Ware; also large rooms (cf. Ahar, Gilund). The terracotta cakes and the perforated jars disappear.

Rao (Rao 62-63) has tried to prove that the L.R. Ware is an evolution from the Harappan pottery complex. A preponderance of the coarse red ware in Pd IIC suggests to him non-availability of fine alluvial clay, hence extra ornament on some wares. But how do we explain the appearance of the L.R. Ware at other sites. The L. R. Ware is technologically an innovation. The pot is 'wet-smoothed' with haematite and then fired. Paintings are done after firing. This again probably reflects some new impulse.

Significant is the increase in the number of the graffito-marked sherds in Pds IIC and III, as compared to Pds IIA and B. From the excavator's report (Rao 62-63), however, it is not clear what graffito belongs to which phase. About 50% graffiti are completely dissimilar; of the remaining 50% not all show close resemblance to the Indus letters. In fact, the appearance of a sun symbol (Rao's Symbol Nos. 59, 60), tent (No. 96) and a horse rider (No. 97) may point to a new element.

Pd III is marked by the emergence of the L. R. Ware as the chief ware. Geometric motifs find preference on naturalistic ones. The pottery shapes also show change. The B-&-R Ware too becomes very popular. The faience and steatite beads vanish; terracotta beads are in fashion. The terracotta bulls, the horse with mane (?) are other important finds.

Of the total 18 copper implements the distribution is: Pd IIA, 7; Pd IIB, 1; Pd IIC, 9; and Pd III, 1. Though tin alloying is known, the technology is not developed (Chapter 5). We will later examine the possibility or otherwise of using the local ores, e.g. from Rupavati in Damnagar Taluka of Amreli District.

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*Hence-forward the Lustrous Red Ware is referred to as L. R. Ware.

Though the crested guided-ridge technique was probably known, the long ribbon flakes are almost absent, because of the non-availability of chert. Even chalcedony is rare. The small pebbles of agate and jasper that were available at Rangpur and Devalia could give flakes only, hence extreme shortage of blades. The availability of fresh copper deposits (Chapter 5) may also be responsible for the extreme scarcity of stone blade tools.

Unfortunately, none of the sites which show devolution of the Harappa culture, e.g. Rangpur, Desalpur, Prabhas, Somnath have been dated by the C^{14} method. The whole of Saurashtra peninsula shows transformation of the Harappa culture into later new forms and is very important to date to determine the chronology of this transition.

The excavations at PRABHAS PATAN, District Sorath, near Somnath, yielded a six-fold sequence (IAR 56-57). Pd I has the late Harappan pottery, microlithic blade industry, and segmented faience beads. Pd IB shows a commingling of the late Harappan and the central Chalcolithic rounded bowls with panelled designs. Some sherds with brown paint on cream base recall Ahar. In Pd IIA the L.R. Ware, new sophisticated motifs on the Black-on-Red ware, and two sherds with antelope appear. A rubble pavement also. Pd IIB shows decline of the L. R. Ware and emergence of the plain slipped red wares. Pd III has the B-&-R Ware with iron.

SOMNATH, (IAR 55-56) about 2 miles from Prabhas Patan, in Pd I yielded the L. R. Ware of Rangpur II, together with carinated bowls and the coarse grey ware. The dish-on-stand was a popular shape. The B-&-R Ware is in smaller quantities. Ten thousand minute steatite beads, a copper celt, blades, flakes and cores, are the other finds. Pd II was characterised by the L. R. Ware, though not so well decorated. The B-&-R Ware persisted. Pd III was marked by the domination of a finely burnished B-&-R Ware with a wide variety of bowls and dishes. A red ware persists, thus showing continuity with the earlier period.

AMRA (IAR 55-56), (District Halar) excavations yielded the Harappan pottery along with the B-&-R Ware in Pd I. Pds II and III are also similar to Lakhabhawal (IAR 55-56), about three miles from the former sites. At Lakhabhawal, Pd I is akin to Rangpur I, with an admixture of buff-slipped greyish sherds. Pd II contained the red polished ware and considerable quantities of the coarse B-&-R Ware. An ear-ring of gold with fine filigree work was also discovered from this period.

DESALPUR (District Kutch) is another interesting two period site (IAR 63-64). In Pd IA the assemblage is Harappan. The fortification having a stone veneer, with bastions, is a remarkable feature. The mud-bricks used are of 50 × 25 × 12.5 cms. size. The houses were built against the fort wall. A thin grey ware painted with bluish green pigment has affinity with the 'glazed ware' of Mohenjodaro.

In Pd IB the cream-slipped bichrome ware was represented essentially in the dish and bowl forms. The painted designs are in black, purple or reddish brown. The plain as well as the grey painted B-&-R Ware is another innovation of this sub-period. The L. R. Ware was totally absent from the site.

Knives, chisels, rods and rings of copper are met with. Chert ribbon-flakes were also found.

Pd II has structures using stone rifled from the fortification. The red- and cream-slipped pottery painted in black, was in vogue.

There is evidence of the uplift of the Makran coast (D 62). Raikes (R 64) suggested that the whole area south-east of Amri including Kutch was under the sea in the Harappan period. Rao (Rao 62-63) also pleaded for a sea route for the migration of the Harappans to Saurashtra. But recent explorations by Joshi (J 66) have shown a number of Harappan sites in the Kutch area thus precluding any possibility of this region being under the sea, at least in the Harappan times.

CENTRAL INDIA AND MAHARASHTRA

Most of the Maharashtra is characterised by the occurrence of black-cotton soil, interspersed with ridges of deciduous and mixed deciduous monsoon forests. For the Chalcolithic people, practising agriculture and probably animal husbandry, the areas of central Deccan with dry deciduous forests and granitoid hills with basalt and dolerite dykes would have been quite suitable. The narrow Narmada basin is quite similar to the Tapti and Godavari valleys. Most of the Indian rivers flow horizontally. In central and south India they form narrow basins divided by plateaux and hills thus imposing limits on large scale agriculture and also on mutual contacts. The sites on river Chambal did not have any alluvial strips worth the name. Possibly Chambal sites (Fig. 1) owe their existence as the supplier of semi-precious stones for tools.

We begin our survey with the northern-most site, ERAN, on Betwa river, in District Sagar (IAR 60-61, 61-62, 62-63, 63-64, 64-65). The site is on a plateau north of the Vindhyan range, a fact, probably responsible for the individuality of its culture. It yielded a four-fold sequence: Pd I being Chalcolithic; Pd II marking the advent of iron; and the remaining two are late.

Pd I is marked by the occurrence of the white painted B-&-R Ware, the black-on-red ware, a painted grey ware (different from the P. G. Ware). In the middle phase a ware with shining deep-red slip appears (Is it L. R. Ware ?). The last Phase is marked by the channel spouts as also a mud rampart (basal width, 45 m). with a moat. These ground-stone celts appear in the make-up of the rampart as also from the habitation of the late phase. Microliths are in plenty. The details of copper artifacts, if any, except for a reported lump, are not available.

Pd II is marked by the advent of iron, the B-&-R Ware (different in shape and fabric than of Pd I) and a rare occurrence of the Northern Black Polished Ware*. Punch-marked coins also appear.

NAGDA (IAR 55-56), a site on Chambal River, is located on a plateau bereft of flat alluvial plains. Pd I has a 22′ thick deposit marked by the black-on-red and black-on-cream wares. A rich repertoire of designs with Central Indian affinities were met with. Gazelles, sun symbol, antlers are depicted. The massive structures of mud bricks and mud mark the residential buildings. Blades and cores of chalcedony, quartz and carnelian were also found. Terracotta beads, whorls with incised designs (cf. Ahar) were also met with. Pd II was marked by the disappearance of the black-and-cream ware and the emergence of the B-&-R Ware. The mud and mud-brick buildings continued. Pd III heralds the N. B. P.

The copper was 'limited'.

Except for the narrow Narmada basin, Malwa plateau is a rocky region with patches of regur soil. Varieties of wild rice are found in the marshy areas. The thin cultivable strips imposed obvious limitations on the expansion of the farming communities (Chapter 7).

KAYATHA** (Wa pc), 15 miles from Ujjain, is a unique Chalcolithic site (In Pd I, as periodised by the first excavator, it yields only Middle Stone Age tools). Pd II is marked by a sturdy ware and microliths. There is a unique orange red-on-buff ware, also a ware with chocolate slip. The latter has some vague Pre-Harappan affinities. Also found in the Pd II are two superbly cast copper celts, chisel and bangles. I could not find any Harappan affinity in Pd II assemblage. Pd III is characterised by the white painted B-&-R Ware and Pd IV by the Malwa ware. The incised designs on the B-&-R Ware are a unique feature of the site.

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*The Northern Black Polished Ware will henceforward be referred to as N.B.P.

**Description based mostly on personal observations and private communication. No published references are available.

The unique nature of the Kayatha culture (Pd II) makes an independent origin of the Chalcolithic cultures highly probable.

MAHESHWAR and NAVDATOLI (SSD 58; S 62-63) on the Narmada, about 50 miles south of Indore, have yielded a comprehensive evidence of the Chalcolithic period there. The people used to live in square or round huts (from 3′-8′ diameter). In Pd II the average size of a room was 10′×8′. An average village may have 50 to 75 huts. Interesting is the evidence of 4′×4′ pit, around which there were postholes; inside the pit were two logs at right angles and remains of two pots with ovalish body and corrugated neck and base.

Pottery: the main ware is Malwa which occurs throughout the Chalcolithic habitation; the B-&-R Ware with white paintings is confined to Pd I; the white slipped ware occurs only in Pds I and II; Pd III shows the channelled spouts (in Malwa fabric) and the Jorwe Ware. The channelled spout has been compared with the West Asiatic analogues. A copper type has been found in Khurdi.

In the Pd I people ate cereals like lentil, blackgram, green gram, peas and wheat. However, in Pd II, rice, though scarce, appears in the dietary. *Oryza sativa* is known to occur wild in many parts of India including central India (V 67-68). The remains of cattle, pig, sheep, goat, and deer show a non-vegetarian diet.

A large number of short parallel-sided blades were used; also serrated blades; lunates may have been used for arrowheads hence not many encountered in the habitation. Flat axes, fishhooks, midribbed blade of copper are also available. Agate, carnelian and faience beads found. Also bangles and rings of clay and copper.

Geologically PRAKASH also falls in the Deccan trap region which comprises of both non-vescicular dark trap and the fragile pink vescicular rock. The latter abounds in secondary minerals like chalcedony, agate, etc. Cherty nodules are also available. These materials were responsible for the prolific stone industry of Prakash which is located on the confluence of Gomai and Tapti. Geographically the Tapti valley is a transition zone between the Deccan and central India. The cultural assemblage of Prakash also shows a commingling of the cultural elements of the Deccan and central India. Several other Chalcolithic sites have been reported in the course of explorations on River Tapti (IAR 58-59).

The excellent report (Th 67) on Prakash excavations gives a four period sequence, with iron emerging in Pd II. Pd IA has blades, microliths, hammerstones, a lump of copper, beads of jasper, carnelian, paste, terracotta toycart. There were four wares: (i) the Pale-Grey ware with white painted designs; (ii) the Malwa

Ware; (iii) the Incised and the Applique Decorated ware; (iv) the Coarse Burnished and Plain wares. This variety is related to the B-&-R Ware.

Pd IB is distinguished by the intrusion of two more wares: (i) the Jorwe Ware and ; (ii) the L. R. Ware. A larger percentage of parallel sided blades were found in this sub-period; trapezes were absent. No structural remains and no house plans were there in Pd I. Pd II is marked by iron, the B-&-R Ware, the N.B.P., as also 21 objects of copper.

The occurrence of only a lump of copper in Pd I may indicate scarcity of the metal.

BAHAL, on Girna River (IAR 56-57), yielded the thick grey ware in Pd IA of Brahmagiri facies. A few sherds of thinner grey with red ochre painting on the rims were also recovered. Pd IB brings a fine wheel-made red ware; also the L.R. Ware. The Jorwe Ware occurs in the upper levels of this period. Parallel sided blades, also trapezes and lunates, beads of paste, shell and clay, and a copper lump form the associated assemblage. Pd II is marked by iron and the burnished B-&-R Ware.

TEKWADA (IAR 56-57), across Girna, yielded four burials assigned by Deshpande to Bahal IB. There were urn-burials consisting of big jars covered with bowls containing a few bones and a few B-&-R Ware bowls with some graffiti (Rangpur graffiti Nos. 21 and 32 have some affinity with these). In one of the jars were found a few beads of carnelian and steatite.

"The pit-burial contained skeleton of an adult, 5′ 2″, laid in north-south direction, with two pots, one of fine grey ware and the other of painted B-&-R Ware, near its feet. These pots, together with a globular vessel of red slipped ware bearing paintings in black curvilinear lines forming a shell pattern and joined together by a band and with six oblique strokes at the top of each curved loop, pointed indubitably to the contemporaneity of the burials with Pd IB of the Chalcolithic culture of Bahal" (IAR 56-57).

DAIMABAD (District Ahmadnagar), on Pravara, a tributary of Godavari, was excavated by Deshpande (IAR 58-59). In this western area the Godavari basin is very narrow as these rivers now drain into the Bay of Bengal, unlike Narmada and Tapti. Here Phase I is marked by a thick, coarse grey ware of Brahmagiri I vintage. Rims of bowls and tips of lids were often painted with ochre. The decorations were in incised and applied techniques. A buff jar with jungle scenes in two compartments, though unstratified, is supposed to belong to this phase. Parallel-sided blades of chalcedony and terracotta and semi-precious stone beads also found. Phase II shows predominance of the black-on-red pottery of medium fabric and channel spout. Painting motifs are geometric. Besides microliths, a fragmentary copper celt, a pin-head and a fragmentary knife represent metal repertoire. Terracottas are a dog and a humped bull. In Phase III, Jorwe Ware dominates spouted vessels ; grey wares persist. Microliths in large numbers, stone mace heads, spindle whorls of pottery, two terracotta human figurines and a terracotta dog were also found.

The burials are extended in Phase I within habitation area, skull pointing north. In Phase II also are extended burials, pointing north-south. No funerary goods were present. In Phase III a skeleton, damaged below the knees, was lying 'in state' over a rammed clay floor with fourteen postholes denoting possibly a canopy over it. Children were buried in urns only.

NEVASA, on the Pravara, is a single culture 'Nevasa-Jorwe' site (SDA 60). The geographical setting of Daimabad and Nevasa are similar. The houses were built of posts and mud walls: both square and round. Storage jars and saddle querns were found in the houses. Ovens were also met with.

A pale grey ware, made on a turntable, has bowls, *lotas* and globular vessels of various types. The other is Jorwe Ware, made from well levigated clay, giving a metallic ring, painted in black on matt red surface. *Thalis* are conspicuous by their absence in this ware. The decoration is mostly geometric; though delineation of a dog and deer is reported. Presence of flax, wild silk and cotton indicate probably textile fabrics. The beads were of a variety of semi-precious stones, terracotta, faience, steatite, also of copper and gold. A child skeleton had a copper-bead necklace on the neck.

Copper, though not plenty, is depicted by flat axes, bangle pieces, beads, rod, a vessel fragment etc. For common use, however, chalcedony blades were used. Heavy work was taken with polished axes of dolerite. Large number of chalcedony blades and 'points', flat copper axes, and slingballs were weapons probably.

Presence of millet, bones of cattle, sheep, goat, and buffalo, snails and shells indicate the dietary items.

Burials in the house or outside were both in vogue. Child burial was done in urns; in one, two or even three urns. Adult burials, over 14 years old, were done in either a single big jar, or double jars or even in 5 jars. Skeletal remains are not well preserved. However, from one case, Ehrhardt thinks that prognathy, broad face, wide nose, long head may indicate an affinity with the primitives of the adjoining jungles. The funerary pots accompanied the burials.

The JORWE excavations (SD 55) also yielded similar assemblage. Flat celts and bangles of copper deserve mention.

CHANDOLI, on Chod river, District Poona, is a single culture site (DAn 65). The evidence of postholes, hydraulic lime flooring, and hearths was discovered. The pottery comprised of the Jorwe, the Malwa, the cream slipped, and the B-&-R Wares. The last two were not discovered at Nevasa. The Malwa Ware shapes were as at Navdatoli; the L. R. Ware also was met with.

The microliths comprised of parallel sided pen-knife blades, trapezes, lunates and triangles. Huge querns, anvils, mace heads of stone were met with ; also a polished stone celt of dolerite.

A theriomorphic bottle (of bull like animal) of pottery is reminiscent of Hissar and Sialk.

Two chisels, a celt, leg ornament, an antennae hilted dagger with midrib, all of copper, too were reported.

MASKI is, normally speaking, outside the pale of the present survey as it is south of the Godavari and forms part of the southern neolithic. But it typifies the cultural relations between the north and the south, hence has been included. Located on the Maski river, a tributary of Tungabhadra, the site is surrounded by gneissic outcrops on three sides and is just outside the Raichur Doab. The auriferous quartz reefs have been the main attraction of the area. However, from the limited excavations, only two gold objects have been reported from Pd II.

The site is situated in District Raichur, Lingsugur Taluk. It was excavated by Thapar (Th 57). The site shows a fourfold sequence; the early historic period beginning with Pd III. Pd I was marked by a profusion of microliths and blades. Chert blades are of ribbonflake long variety and recall Harappan blades. However, no ground stone axes were recovered from the excavations. Only a rod of copper marks the metal industry. The beads are of paste and semiprecious stones. A paste bead of concave sided square (starlike) was a significant type. The pottery is of two types: (i) the dull grey ware and; (ii) the pinkish buff ware. The latter ware had a greater frequency in the lower levels. A painted ware (about 24 sherds only) mainly confined to the lower levels is not comparable with the central Indian fabrics.

Fresh water mussel, rat, cattle, buffalo, sheep, goat bones are found and may indicate food habits. No house plans are available.

Pd II is marked by the megaliths, the B-&-R Ware and iron.

A cylinder seal depicting an elephant driven by a man was discovered from surface in Maski and is now in Nagpur Museum, On the basis of this seal, the chert blades of ribbonflake type and the painted pottery tradition Thapar (Th 57) postulated vague Harappan links.

PROBLEMS AND DISCUSSION

From this survey of the Chalcolithic cultures we see that at Rangpur the Harappa culture devolves into later cultures though the precise nature of transmission has to be worked out. In Pd IIB, there is widespread degeneration and decay. But in Pd IIC there is a resurgence as evidenced by a profusion in paintings, a popularity of the B-&-R Ware and the presence of larger rooms. The graffito-marks also show tent, rider (?) and sun. Fifty percent of the graffito-marks are completely dissimilar to the Indus symbols. The rest too have no marked similarities. It appears that no script was being used; probably there was none at this period. In Pd III, the L. R. Ware becomes dominant; the B-&-R Ware is still popular. Does it suggest that in Pd IIc a new impulse, a new people (intruders) are coming who are responsible for the resurgence, the abundance of pottery traditions, the predilection for the B-&-R Ware and the L. R. Ware ? This evidence is repeated in Desalpar IIb.

At the Banasian sites we see this process in its full bloom. We have big communal hearths, large houses of 30'×15', even of 100'×80' ! A kiln-burnt brick structure had a wall of 37' ! A profusion of pottery styles, the popularity of the B-&-R Ware, the use of the Indus type gamesman, burnt-brick etc. do indicate Harappan borrowings. Or was it that Harappan craftsmen were catering to the new masters (intruders). We will see in Chapter 3 that the end of Mohenjodaro and the emergence of the Banas culture are both datable to *ca.* 2000 B. C. This coincidence is significant indeed. The foreign affinities in the pottery style and the spindle whorls have been noted (S 63) before.

The same story is repeated at the other Saurashtran sites e.g. Prabhas Patan, Lakhabhawal, Somnath etc.

What does this resurgence imply ? Is it a continuation of the Harappan culture only, or is it due to some new impulse, new people ?

An answer to this question may be indicated by a comparison of the copper-technology. Are the new people using new ores and different metallurgical techniques ?

Is the Navdatoli copper metallurgy derived from the Banasian, or from the Pre-Harappan or the Harappan sources ? In Ahar and Gilund stone blade industry is virtually absent whereas there is clear evidence of copper-smelting. Does a complete absence of the stone blade industry imply alien traditions and people ? But what is the status of the copper metallurgy of the Banasians in comparison to the Harappans ? Does it differ significantly from that of the areas of direct transmission like Saurashtra ?

How does the copper technology help us distinguish the three groups of post Harappa cultures of Saurashtra, central India and the Deccan, and south Rajasthan ? How does the ecology affect the technology in these three regions ?

Does the emergence of rice in Pd II at Navdatoli mean new people or just a cultivation of the locally available wild variety of *Oryza sativa*.

In Nagda, further north, the black-and-cream ware disappears in Pd II, and the B-&-R Ware emerges. There is no B-&-R Ware in Jorwe and Nevasa; at Maski it's of iron age. Are the urn burials and the grey ware (handmade) southern neolithic contributions to the Chalcolithic cultures ? Sarma (Sar 67-68) derives the channelled bowls from a south-eastern (Indian) neolithic culture and does not deem it to be part of Malwa culture. What do these facts indicate ?

Could the Malwa and Jorwe people exploit black-cotton soil for agriculture ? Was it possible with their copper technology ? Or could they use only the narrow alluvial strips along the river valleys ? What is the bearing of their ecology and technology in not achieving urbanisation ?

Is the B-&-R Ware a unified tradition, at least before the first millennium ? How does it spread ? Does it penetrate the Doab ? What ecological barriers does the B-&-R Ware dispersal face ? What are its implications ?

These are some of the leading questions that emerge from this survey which will also be tackled in the following chapters.

2. IV. *P. G. Ware Culture*

In this section we will cover, besides the P. G. Ware, the beginning of the N. B. P. too. In presenting the evidence of the protohistoric sites of the Doab, for convenience of presentation, the Ochre Colour Ware* sites have also been included.

THE DOAB

The Ganga basin, or the Doab, is very distinct from the Thar desert or from semi-arid Panjab and Sind. It is a distinct ecological unit. The ecological evidence and its far-reaching implications will be discussed later (Chapters 7 and 8).

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* Henceforward referred to as O. C. Ware.

In surveying the Doab, the Copper Hoards have the first priority. Barring a sprinkling of the Harappan sites on the western fringe, these Hoards have been regarded as the earliest archaeological remains. Heine Geldern (Hg 36) identified these Hoards with the Aryan invaders and Piggot (Pi 50) saw in them the Harappan refugees. Lal (Lal 51), differing from both, argued for an indigenous origin — probably tribal.

Unfortunately none of the Hoards have been found from stratified deposits. At Rajpur Parsu, Bisauli and Bahadrabad—all three Copper Hoards sites—the O.C. Ware was discovered in later excavations. Thus there is only circumstantial evidence of the association of the two.

At BAHADRABAD, the dish-on-stand with a short stem, the pedestalled bowl, and the basins indicate Harappan affinities. Similar pottery has been recovered from Bhatpura, Manpura and some other sites. The evidence at Bargaon is also akin to them.

But in the absence of a definite material assemblage associated with the Copper Hoards, it would not be worthwhile speculating here. The Copper Hoards repertoire will be analysed in Chapter 6, as we have only tools to deal with.

BARGAON (Tehsil Nakur, District Saharanpur) has yielded dish-on-stand and Indus type goblets. The upper levels probably have Cemetery-H influence. Cord impressions, like that of Bahadrabad, as also the O. C. Ware type pottery are reported. The ring stands have chevron-like incised decoration. Terracotta cakes of oval shape, a chert blade, a bone point, terracotta wheel with central hub, stone weights, and faience bangles are also encountered. The upper levels show a greater variety of paintings including cross-hatched triangles set within horizontal bands, wavy lines, etc. A copper-ring of a type reported from Pondi and Bahadrabad also was found here in a typical late Harappan assemblage (IAR 63-64; Des 65).

AMBKHERI (District Saharanpur) yielded (IAR 63-64; Des 65) the O.C. Ware sherds with intact slip without any traces of paintings. No incised pottery like Atranjikhera or Panjab sites was found. The presence of a fine deluxe oval flask, with a base, again suggests the Cemetery-H influence. The other shapes are: dish-on-stand with short stem; bowl-like lids with central knob; basins with hooked rims; miniature cups; Bara-type vases with flanged rim. The humped bull and the terracotta cakes may suggest Harappan ancestry. (I however found that the cakes are much different from the Harappan triangular cakes). No copper object was encountered. Handmade bricks of different sizes were used. The remnants of a brick kiln was also available.

A dull red ware with wave or ripple decoration in relief is met with which is an associate of the P.G. Ware complex also. This may indicate a continuity. Deshpande calls Ambkheri as degenerate Harappan.

ATRANJIKHERA, in District Etah, is being excavated by Gaur (IAR 62-63, 63-64, 65-66; Ga 65). The site has unfolded a long sequence: Pd I has yielded the O. C. Ware; Pd II, the B-&-R Ware ; Pd III, the P. G. Ware ; III, the P.G. Ware ; Pd IV, the N. B. P.

In Pd I the O. C. Ware sherds are wheelmade, porous and fragile, and of thick fabric. The presence of sand, as evidence of flood, in the deposits is definite. Complete absence of regular habitational deposits, in fact, suggests that these are all eroded and detrital deposits. The common pottery types are : vase with flanged rim; basins including that with channel-like spouts below the rim; bowl; a likely piece of a dish-on-stand. Incised designs and a fragment of a pot with black-on-tan-slipped surface were also met with.

Gaur (Ga 65) says, "It has not been possible to establish so far a definite affinity between the finds of Ambkheri and Atranjikhera while many pot-types at Ambkheri appear to have Harappan affinities, those found at Atranjikhera bear no such trace and look different. . . .This may imply some contact between the two cultures but certainly no direct affinity."

Pd II has a thin deposit of 25-50 cm. over an approximate area of 300 sq. m. which was marked by the occurrence of the B-&-R Ware. The pottery complex has, besides the B-&-R Ware, the black-slipped, the red-slipped and the plain red wares. The O. C. Ware and the P. G. Ware are completely absent in this period. The shapes in black slipped ware were the same as in the B-&-R Ware. The latter shows affinities in fabric with the Banasian B-&-R Ware. The B-&-R and the black-slipped wares are both of a fine quality, made of well-levigated clay, generally thin and well-burnt. The high quality of the lustre was perhaps due to burnishing. Besides the usual wheel turned pots, a few were handmade. The black-slipped ware is occasionally painted with designs similar to those commonly found in the P.G. Ware.

Charred bones were collected from the square and oblong hearths. A few burnt fragments of bricks of a uniform size of 14.5 × 9.5 × 3.5 cm. were recovered. Their use is unknown.

Cores of chalcedony and waste flakes were met with again, though none are definite tools.

An earth filling, of the P. G. Ware period, intervenes between the B-&-R Ware and the P. G. Ware deposits. "It appears that the B-&-R Ware occupation had been brought to a close by a flood which washed away a considerable portion of the strata leaving only a thin deposit of this culture."

The excavator has emphasised the affinity of the B-&-R Ware of Atranjikhera with that of Ahar-Gilund, especially in fabric.

Pd III has a deposit of 0.8 to 2 m. spread over an area of about 600 sq. yards which represents the P. G. Ware culture. It has been divided into five subphases. A large number of domestic (size 25 × 35 cm.) and community hearths of circular shape were met with. The presence of postholes over thick mud floors suggests thatched roofing over bamboo or wooden posts.

The small percentage of the P.G. Ware (3-10%) in the total pottery assemblage may indicate its deluxe nature. Alongside the B-&-R Ware, the black-slipped, the slipped and plain red wares continue. The P. G. Ware and the plain grey ware show a remarkable similarity in shape, fabric and technique to the B-&-R Ware and the black-slipped of the previous period. In the early subphase the black-slipped and the B-&-R Wares predominate. In the second, third and fourth, the P. G. Ware percentage is the highest of all the subphases. In the last subphase the P. G. Ware declines. In this late phase the N.B.P. also appears but without any red ware shapes of carinated *handi*, pear-shaped vases, etc. In Pd IV, the P. G. Ware and plain grey wares continue, though in a cruder form, and finally vanish.

The terracotta objects include plain and incised discs, hand-made human figurines, pendants, toys, beads, bangles. Two sherds bear cloth-impressions.

The iron objects include spearheads, arrowheads, knives, axe, kitchen tongs and fish hooks.

ALAMGIRPUR, on the river Hindon, in District Meerut, made history by bringing the Harappans inside the Doab (IAR 58-59). Pd I yielded a late variety of the Harappa culture. Pd II is marked by the P. G. Ware accompanied by the B-&-R Ware, the black-slipped and plain red wares. Sometimes mica has been used as a *degraissant*. Wheeled terracotta objects, dice, styli, pins and arrow-heads of bone, glass beads are also met with. Pd III marks advent of the N. B. P.

The first occurrence of iron was reported from the P. G. Ware levels at this site. Copper continues in use, but iron too occurs throughout the period, denoted by barbed arrowheads, spearhead, nail and pins.

HASTINAPUR, in Mawana Tehsil (District Meerut), on Budhi Ganga, was excavated by Lal (Lal 51). Pd I is marked by a deposit of brown clay varying in depth from 1′-1.5 representing the O: C. Ware levels. A few sherds of red ware with the colour rubbing off were discovered. It could not be ascertained whether the ware was wheel-made. In some cases a red slip was visible. No definite forms could be made out. The whole assemblage seemed to be rolled about.

This pottery has been compared with the O. C. Ware at Rajpur Parsu, Bisauli, from where the Copper Hoards too were reported. Atranjikhera and Ambkheri also have yielded the same ware. Everywhere the look of the ware is the same and the deposits look like eroded material rather than a habitational debris.

Pd II is characterised by the presence of the P. G. Ware. This is a grey ware, mostly wheel-made, though a few handmade examples are also there. The paint is prefired. The motifs mainly are: bands; groups of vertical; oblique or criss-cross lines usually on the exterior; rows of dots and dashes; concentric circles or semicircles; sigmas and swastikas. Alongside, though on a smaller scale, was a ware with grey core, reddish-brown slip, painted in deep-chocolate colour. Some sherds had black-and-red exterior. The Black slipped ware seems to be a forerunner of the N.B.P. Evidence of mud plaster with reed marks is met with, though no houseplans were recovered. A fragmentary burnt brick did occur. Two chert and jasper weights, terracotta bull (?) and horse (?), discs, stamps, beads of agate, jasper, carnelian and bone are the other finds. A reel shaped object of bone may be a gaming piece. Several bone styli were also met with.

Rice was recovered. Animal remains of humped cattle, sheep and pig show their use in economy. Clear evidence of eating pork, beef, venison is there. Skeletal remains of horse (*Equus caballus*) too were found. The importance of the horse and the rice *vis-a-vis* the Aryans will be discussed in Chapter 7.

The copper objects included an arrowhead, a nail pairer, a borer, and an antimony rod. Most important is the presence of iron ore and slag (?) from the upper levels of Pd II. If they are really so, it would prove the beginning of real iron smelting.

Pd III starts after a flood which marked the end of Pd II. Pd III is distinguished by the N. B. P.

(RUPAR too yielded a deposit of the P. G. Ware, but details are not available.)

At CHIRAND, district Saran, Bihar, Pd II marked (IAR 63-64) the beginning of the N.B.P. Pd IA is distinguished by the occurrence of the white painted B-&-R Ware with microliths and a restricted use of copper; also, by the plain and painted black ware and a few pieces of steel grey and red wares. The important shapes are dish-on-stand (also with corrugated stems), long necked jars, basin, perforated vessels, lipped bowl, four legged lipped jug, trough and dish. The other finds include terracotta beads and bone arrowheads. Pd IB marks the advent of iron, other assemblages otherwise continue as before.

RAJARDHIBI is situated in Ajay valley, in district Burdwan. It is a task to gather useful data from the poetic report (Dag 64). Pd I is marked by mud houses, handmade greyish or pale red pottery of thick fabric and microliths. The burials show east-west orientation and are fractional in nature with the upper parts missing. Pd II shows a paved lane, flanking two houses. The houses have a systematic layout. The ceramic is composed of the B-&-R Ware, the painted red and the L. R. Ware. The paintings are in black or whitish pigment. Fine fabric and levigated clay are used. The motifs are solid triangles, lattices, hatches and lozenges, and wavy lines flanked by sigmas. Dasgupta has traced affinities with Alicar Hüyuk in the bridge spout, the footed goblets and the handled vases. The extended and secondary burials are met with in this period. Copper bangles including a spiral was discovered from the burials. Bone arrow-heads and awls also met with. There is a radiocarbon date,* 1012±120 B. C., for this period. Pd III is similar to Pd II in pottery. Polished stone celts, bone tools also were found. Iron tools were popular in this period. Pd IV, subphase A, is described as Pre-Mauryan. From this period a round seal was found and was claimed to be Cretan. However, these views are not accepted by the scholars in the field.

PROBLEMS AND DISCUSSION

The P. G. Ware has occupied a crucial place in Indian protohistory. More so, because of Lal's equation of this ware with the early Aryans. We will discuss below some aspects of the P. G. Ware culture and delineate the problems that remain unanswered.

The (P. G. Ware) pottery is a grey ware fabric, made of well-levigated clay and painted with (prefired) geometric designs. At

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* This sample is supposed to have been dated in some Indian C^{14} laboratory, but not in T. I. F. R., Bombay. However, to the best of our knowledge we are not aware of any other C^{14} laboratory in the country.

Atranjikhera we saw that the P. G. Ware constitutes only 3-10% of the total ceramic assemblage. The percentage at Hastinapur is not known. At Atranjikhera, curiously enough, the black slipped designs of Pd II at the site are similar to those of the P. G. Ware of Pd III. Even the shape and the fabric are similar. Again towards the end of Pd III we find the N.B.P. appearing, following the P. G. Ware shapes at Atranjikhera. Deshpande (Des 65) has pointed out that at the O. C. Ware sites he got a dull-red ware with wave or ripple decoration which is an associate of the P. G. Ware. All this appears to denote a basic continuity of people. Could it mean that the P.G. Ware impinged upon the local people? And that the N. B. P., an impulse with an eastern epicentre, showing a smooth transition with the P. G. Ware, represented only trade and ideas from the east?

Curiously, at Atranjikhera, the red ware shapes traditionally associated with the N.B.P., viz., carinated *handi*, pear-shaped vase (Ahichchatra 10A type), etc., do not appear with the emergence of the N. B. P., but come much later. This evidence was repeated at Sravasti (Si 67) where the red ware shapes associated with the N. B. P. are similar to those found with the P. G. Ware at Hastinapur. Does this evidence indicate that on a substratum of the red ware using people impinged the P. G. Ware in the west and the N. B. P. in the east and gradually the two merged?

This may indicate a rough contemporaneity of the P. G. Ware and the N. B. P. for some time. Association of iron too is suggestive of a late date for the P.G. Ware.

We will also see as to what does the N.B.P. and the P. G. Ware contact signify? Did the N. B. P. tradition bring the plentiful iron of Bihar with it? And if so, what did it contribute to the economy? What was its impact?

Did the P. G. Ware people smelt iron in the Doab? When did they start using the local ores?

Was the south ahead in iron technology, in point of time, than the north?

What is the significance of rice and the horse vis-a-vis the Aryans?

If the P. G. Ware represented the early Aryans, how far are they removed from the Harappans? What was the role of iron in colonising the Doab and when and how did it lead to urbanisation?

In what state did they find the Doab? Was it a thick forest to clear which they needed iron?

This is the last group of problems that emerge from the survey of the protohistoric Doab. We will seek clues to their answers too in the following pages.

In the foregoing pages we surveyed first Pre-Harappa and Harappa cultures and formulated the problems that crystallise. Then we described the traits of the other Chalcolithic cultures and delineated the emergent problems. Lastly, we surveyed the cultures of the Doab and the problems thereof. In the following chapters we would discuss the chronology, the technology and the ecology of the protohistoric cultures to seek answers to the problems enumerated in this chapter.

CHAPTER 3

CHRONOLOGY

To give shape to the amorphous looking mass of data, described in Chapter 2, our first task is to discern a chronological order therein. Because, without the ordered frame of reference of absolute chronology, it is rather impossible to delineate the protohistoric cultural pattern in India, as elsewhere. The perspective provided by the temporal and spatial distributions of prehistoric cultures is a must for an understanding of contacts, trade, migrations, successions, influences, and genesis of cultures.

We will also examine the basic premises of archaeological as well as radiocarbon methods in greater detail. This will help us assess the validity of chronologies arrived at later in the chapter.

We will discuss in the following sequence :

- I. Dating Methods
  - A. Archaeological
  - B. Physical
- II. Applications
  - A. Archaeological Dating in India
  - B. C^{14} Dating in India
- III. Conclusions

The Section I is introductory to the Sections II and III which contain my original work of the determination of the C^{14} dates and their analysis, as also the re-examination and re-interpretation of the available archaeological data for dating.

3. I. *Dating Methods*

I.A. ARCHAEOLOGICAL METHODS

Archaeology has borrowed its chronological concepts from geology. But the geological strata and periods have global validity, not so the archaeological ones.

Stratigraphy or succession of deposits does give us a temporal sequence. Though, in practice, the mounds are disturbed by all sorts of pits and dumps. Strata, in the excavations, are mainly recognised by floor levels, structures, foundation trenches etc. Quite often, the archaeologist decides the change of the stratum on the basis of the 'feel', in such cases subjective element cannot be excluded. Attempts are now being made to study the soil stratification on more objective and scientific lines (Co 63).

Stratigraphic excavations were unknown in India before Wheeler's arrival as all excavations were then done by crude 'bench-level' methods.

For a single site, the stratigraphy is really useful. But problems arise when a culture is compared with others. For correlations, use is made of type-fossils, the strata in which they occur are regarded as homotoxial. "Phenomena representing the same stage in an evolutionary series should be called systadial. Those occupying the same relative positions in parallel typological or stratigraphical sequences may be termed as homotaxial" (Ch 56).

Sequences are arrived at by using tripartition methods amongst three groups. "Each group should be characterised by its own distinctive assemblage of types, but some of the distinctive types, normally found in group I, occasionally occur in group II, associated with group II types and vice-versa. Similarly group II types are sometimes found in group III graves and vice-versa, but group I and group III types are never associated together in the same graves. If these conditions be satisfied, the three groups represent as many temporally distinct and consecutive periods" (Ch 56). An elaboration of this method was used by Petrie (Pet 99) in arriving at fifty "sequence dates" for the Egyptian prehistory. But the direction of the sequence has to be determined on the basis of independent parameters, otherwise an inverted sequence may be obtained as was the case when Petrie analysed the Predynastic cemetery.

The major part of the chronology of the Indian protohistoric period is based on the type fossils. The dating of the Harappa culture, for example, is based on the Harappan type-fossils found in Mesopotamian sites. These latter sites are dated on the basis of written records. In such dating, on the basis of datable contacts, we can arrive at only an upper age limit.

The American archaeologists, however, prefer to rely upon the statistical method. Instead of depending upon a few type fossils to distinguish the change in culture or period, they look for the statistical differences in the composition of the total assemblage. In India too such methods have recently been applied (Th 67). However, one has to guard against the pitfalls in the statistical methods.

The cultures, that have a wider spatial distribution, are quite often thought to be flourishing all over the area at the same point in time. For example, the Harappa culture was called an Empire, extending 1000 miles on east-west and a little less on north-south axes (Fig. 1), supposed to be thriving between *ca.* 2500-1500 B. C. Applying the same total time spread to each and every site of a far-flung culture is full of pitfalls, as we will see later.

The theoretical problems of the archaeological ages as technological stages have been discussed in detail by Childe (Ch 44) and will be referred to in Chapter 4. Nor is there any unanimity about the subdivisions of periods, phases etc. These terms have been used very indiscriminately so far. There is urgent need for standardisation.

The problems of terminology have not been solved yet. The demarcation of prehistory and protohistory in India is far from clear. Sinha has recently (Si 67-68) proposed that earlier than *ca.* 1300 B. C. the whole period be included in prehistory. Sankalia (S 66) however is in favour of including the period between the Pre-Harappan to Buddha's times within protohistory. We have retained Sankalia's periodisation.

I.B. PHYSICAL METHODS

These methods depend upon physical laws and thus are more objective. The methods can be divided into the following categories:

(i) Chemical;
(ii) Botanical;
(iii) Geomagnetic;
(iv) Thermoluminescent; and
(v) Radioactive.

Below we will discuss these methods and their potentialities for and role in Indian archaeology. Only the C^{14} method will be discussed in greater detail as it has a crucial bearing on the protohistoric chronology of India, and as it is the only method established as accurate.

B. (i) *Chemical Methods*

The methods are mainly based on chemical analysis and are useful for bone dating. This is a 'relative dating' method and not 'chronometric' as the C^{14} technique is. The bones thus analysed give dates with respect to the environment. For this reason, it is preferable to assay simultaneously for nitrogen, flourine and uranium (Ok 63).

The bones contain organic fraction called collagen and inorganic portions of hydroxyapatite and calcium carbonate (both collagen and calcium carbonate can be dated by C^{14} method also). Bones alter chemically when buried. The degradation of collagen, though widely divergent in different regions, is more or less uniform for a given locality. The rate of the decay of collagen can be estimated by the nitrogen assay of bones.

All ground waters contain fluorine in the form of soluble fluorides. The flourine ions replace the hydroxyl ions from the hydroxyapatite. The bones which have lain for the same length of time in a particular deposit will have approximately the same flourine content. Thus the estimation of fluorine content gives a relative date. On the basis of this method the Swanscombe skull was declared to be older than the Galley Hill skeleton (OM 49). The Piltdown skull forgery was finally proved by using these methods along with C^{14} dating (DO 59).

The ground water also contains traces of uranium, the absorption of which in the bone depends upon the length of time it was buried. The radiometric assay shows that there is a progressive build-up in the average radioactivity of the fossils with increasing geological age. Quite often the three types of assay (of N_2, F and U) are carried out together to cross-check the results.

B. (ii) *Botanical Methods*

Dendrochronology is now a well-established science of dating trees (Bnr 62,63). The trees, in climates showing sharp variations during the year, form clearly demarcated growth rings. By counting these (from the stem of a tree) one can guess its age. The pattern of tree rings is influenced by various long term climate fluctuations also, giving rise to thick or thin annual rings. The skeleton plots (based on the thickness of rings) of cross-sections are then compared with those of older and younger trees. Identical skeleton plots help cross-dating trees of different ages and thus provide time sequences. Very interesting results have been obtained by applying this method (along with C^{14} dating) to the Mayan (SR 60) and the south-west American sites (Sc 56).

Very sophisticated methods are in use (Bnr 63) now. Various measuring devices designed to record the widths accurately along a radius have been developed. Methods of statistical analysis involving coefficients of parallel and opposite variation, logarithmic plotting, special mechanical devices for automatically comparing series, and other innovations have now been devised (Ba 63). In India not much work has been done in this line so far.

Tree ring research can give very useful information about the past climate also and the subject is known as dendroclimatology (Fr 63, 65, 66; FS 65).

The other method is based on palynology or pollen analysis (FI 50). The pollen are male sperm like parts of plants and are produced in large numbers for the propagation of the species. They are characteristic of each species and are very resistant to decay; even hydrofluoric acid does not attack them. The pollen analysis (Di 63) can help the archaeologist in three ways : a) for dating purposes; (b) for the reconstruction of ecology and; (c) to see the role of man in it.

"For many parts of the world a pattern of change has now been established in the pollen rain over a long period of the past, so that even isolated analyses may be fitted in the sequence" (Di 63). Though for the protohistoric periods their dating value is limited, yet the ecological importance (GH 57) is great (Chapter 7). In India the botanists of Sahni Institute of Palaeobotony, Lucknow, (V 65, 67-68; Sin 63) have taken up the work of evolving a pollen-sequence for the Quaternary Period with the help of C^{14} Dating.

B. (iii) *Geomagnetic Method*

The geomagnetic method depends upon the property of the clays to acquire thermoremanent magnetism. The clays containing magnetic oxides of iron, when heated beyond the Curie point lose their magnetism. Between the Curie point and the "blocking temperature" these baked clays (terracotta, pottery) acquire the direction and the proportionate intensity of the ambient magnetic field. Thus they become permanent records of the earth's magnetic field. This effect can be detected later. If we have a graph of the changes in earth's magnetic field with respect to time, we can compare the thermoremanent magnetism of undated old potsherds with the past changes and thus date them. Thellier (TT 59) has done work in this field in France and others in England (Wea 66; AH 66; Hu 66; BM 67).

Athawale carried out this type of work at the Tata Institute of Fundamental Research, Bombay. Samples from about 30 Indian Archaeological sites dating from *ca.* 300 to 4000 B.P. were measured. The results show that over the past 4000 years the average field was not much different from the present—in fact it was lower only by about 15%. But the results of Thellier indicate an increase in the field intensity in the past with the peak of 1.6 times the present value for 2000 B. P. samples. The Japanese results (N 63) show sharp increase for 2000 year-old basalt samples, and an equally sharp decline to present value for the 3000 year-old sample. Thus, at the moment, due to this divergence in results we cannot use this method for dating on a world-wide scale.

B. (iv) *Thermoluminescence*

In small concentrations (ppm range) all pottery contains radioactive impurities like uranium and thorium. The α-particles emitted by them bombard the other constituents of the clay and raise the electrons to meta-stable levels. When the pottery is fired each electron falls back to its stable position and emits a photon of light, this phenomenon is termed as thermoluminescence. The longer the potsherd has been crystallised, the more ionising radiation will have been resulted and the more trapped electrons will be held in the crystal structure. The observed thermoluminescence, on reheating an old potsherd, is representative of the accumulated radiation damage and thus of the time elapsed since the original firing of the pottery. Recently fired pottery should thus show no thermoluminescence.

Many workers (AT 64; MZ 66; RH 66; Ti 66; Fl 66; RR 66; Z 67) have been engaged in developing this method for dating the pottery. Though the principle is straightforward, yet many uncertainties remain to be resolved.

No work has been done in this field in India so far.

B. (v) *Radiocarbon Dating*

The radiocarbon or C^{14} dating has brought about a great transformation in Indian archaeology, as in the rest of the world. With just 300 C^{14} dates a great deal has been learnt about the various Indian archaeological sites. Willard F. Libby, the father of the method was awarded a Nobel Prize in 1960 in recognition of the value of the method and the theoretical perception behind it.

A byproduct of this method has been a very close collaboration of the physical scientists and the archaeologists. However, since this is a method based largely on nuclear principles and techniques it would be worthwhile discussing it in greater detail. The proper use of any scientific method requires an understanding of its principles, techniques and limitations. Millions of C^{14} dates themselves speak for the success of the method, but the inherent errors, room for refinement and its limitations should not be lost sight of (Ba 58). Here, a balanced and objective discussion of the method would be attempted, without going into finer technical details.

Let us first see how C^{14} is produced and dispersed.

Carbon-14 is produced in the atmosphere by a particular type of interaction of neutrons with nitrogen nuclei. These neutrons, themselves, are formed as a result of the cosmic rays hitting the air-nuclei. This cosmic bullet-shooting results in the fragmentation of the air-nuclei, which give off neutrons. The cosmic ray intensity has not varied significantly in the last millions of years, and thus the C^{14} production rate also has remained constant (AHL 61).

The C^{14} atoms, thus produced, combine with oxygen to form carbon dioxide ($C^{14}O_2$). This ($C^{14}O_2$) and ordinary carbon dioxide ($C^{12}O_2$) are distributed in nature through the carbon cycle. The plants fix carbon dioxide to photosynthesise their food. As plants are consumed by the animals and the humans alike, they are also labelled by C^{14}. Through molecular exchange across the air-sea interface C^{14} reaches the oceans also. Thus the marine biosphere too partakes of it. Through this carbon cycle, C^{14} is dispersed in nature and all the living matter is labelled with it.

When the C^{14} method was developed extensive C^{14} measurements of dendrochronologically and archaeologically dated samples were made and it was found that the living matter always accumulated both ordinary and radio-carbon in fixed proportions $\left(C^{14}/C^{12} = \frac{1}{8 \times 10^{11}}\right)$. Since the time scales of mixing beween the various carbon dioxide reservoirs are small as compared to the long half-life of C^{14} (5730 ± 40 years), the labelled carbon dioxide is uniformly distributed throughout the atmosphere.

The supply of C^{14} stops at the death of the organic matter and C^{14} starts decaying exponentially. The time of death can be measured by using the relation:

$$N_t = N_o \exp\left(-\frac{t \ln 2}{\tau_{1/2}}\right) \quad \cdots (1)$$

where N_t is the number of residual C^{14} atoms, $N_0 = C^{14}$ atoms at the beginning, $\tau_{1/2} = C^{14}$ half-life, t = time elapsed since the time of the death of the organism when the number of C^{14} atoms was N_0.

It is clear from this relation that if we know:

(i) the original number of C^{14} atoms;
(ii) the half-life of C^{14} and;
(iii) the residual number of C^{14} atoms;

we can determine the time (t) elapsed since number of C^{14} atoms was N_0. This will give us the time of the death of the plant or animal, the organic remains of which we are dating.

C^{14}/C^{12} Variations in the Past

In recent years, with more sophistication in detection techniques, it was found that there were probably some fluctuations in the C^{14}/C^{12} ratio in the past. De Vries (De 58) showed a +2% increase in about 1690 A.D., while Suess (Sue 55) demonstrated a variation of -2% from the recent wood; the latter effect was probably caused by the burning of dead (free of C^{14}) fuel. Recent work (Li 63; DL 66; Sue 55, 65, 67; K the) mainly based on the dendrochronologically dated samples from giant trees like Sequoia and Bristlecone pine showed $+2$ to $+6\%$ fluctuations in the period discussed in the present work. In fact, Stuiver (Sti 67) on the basis of sedimentation rate studies and the dendrochronological evidence suggested the relation:

$$T = 1.4\ R - 900 \qquad \dots \quad (2)$$

where T is true age and R is the radiocarbon age in years B.P. When one applies this correction to the Harappan date bracket of *ca.* 2300-2000 B.C. (for the metropolitan areas only) one gets a 'true' timespread of *ca.* 3100-2680 B.C. It is obvious that this is too far fetched to believe. We have definite archaeological evidence of Sargonid and Isin Larsa contacts with the Harappa culture which were confined to *ca.* 2350-2000 B. C. Nobody can believe that Mohenjodaro came to an end in *ca.* 2700 B.C. !

The probable cause for such apparent deviations could well be that all dendrochronological samples come from giant trees which lived for several thousand years. Some radial diffusion or uptake of carbon through the roots could very well give rise to such apparent deviations. In fact, studies on these problems are being carried out by different workers (Ral 68), including our laboratory.

The evidence of the well dated archaeological samples (Sm 64) rules out greater than $+2$ to $+3\%$ deviations in II-III millennia B.C. More work is needed to determine the extent of corrections. The fluctuations are more or less linear and for the period discussed positive. As a result, the whole chronological frame-work may have to be pushed back by a century or more. If these deviations prove to be real to some extent, Wheeler's contention of pushing back the Harappans to *ca.* 2500 B. C. may be vindicated.

However, it should be emphasised that these apparent physical uncertainties make it necessary to term the C^{14} dates as radiocarbon ages of the cultures so dated. They need not be taken as absolute ages, at least at the moment, on the modern calendar. Very soon, the magnitude and the veracity of these deviations will be determined, and thereafter, if necessary, corrections can be applied. At the moment, it should be reiterated that the radiocarbon method alone is most reliable of the physical methods and can be depended upon.

Half-life of radiocarbon

The journal *Radiocarbon* publishes dates on the basis of the 5568 ±30 years value, as the half life of C^{14}, originally used by Libby. However, in a later conference (God 62) it was decided, on the basis of recent measurements, that 5730 ± 40 was a more appropriate working value. I have used the 5730 ± 40 value for all my discussions.

Experimental Techniques

I will briefly describe the techniques that were used for determining the C^{14} dates in our C^{14} laboratory.

First of all the samples were cleaned manually to get rid of the extraneous material. Rootlets were hand picked carefully, as they can be a serious source of contamination. Charcoal samples were pretreated with dilute hydrochloric acid (1%) to remove soil carbonates, if any. For the removal of humic acid, dilute sodium hydroxide (1%) treatment was given.

The sample was first burnt in the presence of pure oxygen to produce carbon dioxide. The carbon dioxide was then hydrogenated to form methane using Anand-Lal (AL 64) technique. All synthesis work was done in a glass vacuum assembly. The techniques used have been described in detail elsewhere (AKL 65). The samples were counted in the form of methane.

The purified methane was filled in Oeschger-Houtermans' gas-proportional counters to measure the specific C^{14} activity. Due to human activity (burning of dead fuel, explosion of nuclear bombs) the natural levels of radiocarbon in the atmosphere have been drastically changed, therefore the present plants cannot be used as modern standards. Hence for modern reference standard 0.95% oxalic acid (produced by the National Bureau of Standards, U.S.A.) activity was used. Anthracite was employed for background. The reproducibility of the counting rates of the standard and background were checked after every 4-5 samples. This ensured prompt detection of changes, if any, in the sensitivities of the counting set-up.

Calculation of Dates

The following relation (3) is used for the calculations of dates. It is essentially derived from relation (1).

$$T = \frac{\tau_{1/2}}{\ln 2} \cdot \ln \frac{O_n \times 0{\cdot}95}{S_n} \qquad \ldots (3)$$

where T is age of the sample, O_n is the net counting rate of N.B.S.

oxalic acid, S_n the net sample counting rate and $\tau_{1/2}$ the C^{14} half-life. Though the counting set up works in an air-conditioned room, minor fluctuations of temperature (1-3° C) do occur causing slight differences in the amount of gas filled in the counter. For this corrections were applied.

The errors were calculated by using the following relation:

$$\triangle T = \frac{\tau_{1/2}}{\ln 2}\left[\frac{S_n + 2B}{S_n^2 t} + \frac{O_n + 2B}{O_n^2 t} + 2f^2 + 2c^2 + \left(\frac{T \ln 2}{\tau_{1/2}} \cdot \frac{\triangle \tau_{1/2}}{\tau_{1/2}}\right)^2\right]^{\frac{1}{2}} \quad (4)$$

where $\triangle T$ is the error (one standard deviation), f is error due to fractionation effect, c is error due to drifts in electronic system, B represents background counting rate, t is the duration of counting and $\triangle \tau_{1/2}$, uncertainty in half-life. The half-life used in our calculations is 5730±40 years.

Significance of Errors

The radioactivity, being a random phenomenon, is governed by the laws of probability. We can calculate the expected deviation for different levels of confidence. For 'one standard deviation' error, the level of confidence is 68.3%. The probabilities of the observed value being correct, within the errors, from the true value, for errors of 1.5, 2, 3 and 3.5 times the standard deviation, are 86.6, 95.5, 99.7 and 99.9%, respectively. The dates given here all refer to one standard deviation error.

The errors are very important in order to assess the order of events. Below, we have inter-compared some sets of two dates to illustrate the point.

First Date	Second Date	Remarks
1990±100	1770±125	Difference of 220 years on mean. Within errors the two are not inconsistent.
1990±100	1740±125	Difference of 250 years on mean. Outsid one standard deviation 68% probability that the second sample is younger.
1990±100	1630±125	Difference of 360 years on mean. Taking two standard deviations on the second date and one on the first, the second sample is still younger. The level of confidence is 95%.

Moreover, a large number of dates should be used to determine the time-spreads of cultures. Due to various reasons, some dates do go divergent; therefore it is always important to rely on clusters of dates, rather than single dates. It has also been observed e.g. in Kalibangan, that the soil-cover does play a crucial role in preserving the samples against contamination. Especially, in single culture sites which are exposed to weathering, the effect of contamination due to humic acids from the decay of modern plants and roots (which have double the natural amount of C^{14} due to nuclear explosions) could be quite large. These problems have been discussed in detail by us elsewhere (AK 68).

When a number of samples derive from the same levels we can obtain a mean date and compound the errors. Suppose we have the following dates :

$$A \pm dA, \; B \pm dB, \; C \pm dC$$

We can obtain the mean result $T \pm dt$ by using the following relation:

$$T \pm dt = \frac{\sum\left[\left(\frac{A}{dA}\right)^2 + \left(\frac{B}{dB}\right)^2 + \cdots\right] \pm \sum\left[\left(\frac{A}{dA}\right)^2 + \left(\frac{B}{dB}\right)^2 + \cdots\right]^{\frac{1}{2}}}{\left[\frac{A}{(dA)^2} + \frac{B}{(dB)^2} + \cdots\cdots\right]} \quad \ldots (5)$$

It should be noted that what is dated is only the death of the organism, whose remains we use for measurements. The C^{14} method never dates an archaeological event directly. If, say, a two hundred years tree was used for fuel, its outer rings would give a 200-year younger date than the core portion. This is known as the post sample growth error. There are other types of stratigraphical problems, as discussed by Tauber (T 58) for bog-sites. Since the association of organic remains and a particular stratum is only circumstantial, it is necessary to go for more measurements. A C^{14} date dates only the organic remains and not an archaeological event. Therefore charred rice and charcoal from short lived trees buried under a proper soil cover make better samples for the C^{14} dating purposes.

3. II. *Applications*

II. A. ARCHAEOLOGICAL DATING IN INDIA

Now I will try to build relative and absolute chronologies of the protohistoric cultures on the basis of the re-examination and reinterpretation of archaeological evidence. It may be pointed out at the outset that, unlike West Asia, there are no written records on which we can base our chronology. Essentially our dating depends upon the appearance of type fossils in a cultural assemblage. For absolute chronology we have to rely on datable contacts with Mesopotamia, quite often via Iran. The difficulties of dating are further compounded by the lack of published reports. Within these limitations we will try to delineate a chronological framework for the cultures covered here. The radiocarbon dating evidence will be treated separately. The two will be integrated in the concluding part of the chapter.

A.(i) *Chronology of Pre-Harappan Cultures*

The northwest, Irano-Afghanistan borderlands, of Indo-Pakistan subcontinent, presents, as we saw in the last chapter, a great cultural diversity. As most of the evidence was accumulated out of the surface explorations of Stein (Ste 29, 31, 37), Majumdar (Maj 34), Hargreaves (Ha 29), de Cardi (Dec. 59, 65), Alcock and Fairservis (Fa 59), it has not been possible to fix the various cultures in their proper places in an absolute chronological framework.

We do not propose to deal with these cultures in detail here. However, the cultures that have yielded copper or have proto-Harappa elements have a direct bearing on our theme and hence have been discussed exhaustively, from a chronological point of view.

The first account of Baluchistan pottery was published by Childe (Ch 33). Piggot (Pi 50) bravely attempted the first comprehensive synthesis of this confused mass of data, based on Childe's account as also his firsthand study of the material. He extended McCown's (Mc 42) observed distributions of red ware domination of north, and buff-ware preponderance in the south Iran, to Baluchistan pottery. Piggot found that Zhob cultures of the north were red ware cultures, and the Buff ware cultures were confined to the south.

The discovery of Togau red ware in Quetta, southwest and even towards the Indus, by de Cardi (Dec 59) put this classification in jeopardy. "Subsequent fieldwork has shown that this distinction is no longer tenable in Baluchistan where red wares now extend south-wards through central Kalat, Buff wares are found in the Quetta region, and identical designs adorn both red and buff wares on a number of sites" (Dec 59). Recent excavations and explorations by Fairservis (Fa 56, 59) and de Cardi (Dec 65) have provided more evidence for correlations, as also Casal's excavations at Mundigak (Cas 61) and Amri (Cas 64).

Fairservis's pioneering work would have been of greater importance but for his methodology. De Cardi (Dec 58) reviewing his Report (Fa 56) comments, "Faced with the difficulty of identifying mud brick buildings, the excavators resorted to a system of digging by 25 cm. levels. It is therefore difficult to correlate the wide variety of plain and decorated wares found in the Quetta valley."

Childe (Ch 56) once said, "To some of our American colleagues the traditional old world practice of defining cultures by a few type fossils and of 'dating' an assemblage by the presence of one or two such type fossils must seem terribly crude and unscientific.' Fairservis too preferred to use a statistical method based on New World experience of 'quantitative analysis of ceramics' of single period sites. His 'periods' thus depended upon the statistical maximal occurrences of pottery types. This led him into serious difficulties, for example in Kili Ghul Mohammad Pd II, which was supposed to be characterised by handmade pottery, the pottery graphs showed 10 wheelmade types out of a total of 12.

There are only two ways of dating these cultures: (i) on the basis of Mesopotamian and Iranian parallels and; (ii) C^{4} dating.

In considering the former, we have to remember the caution advised by Wheeler (W 62a), "How far cultural equations may reflect chronological equations is a matter for constant and cautious considerations in view of the almost unpredictable durability of some of these mountain communities."

In view of all these difficulties, Dales (D 65) used a somewhat novel method for synthesis of this bewildering mass of data. He based his method of stratification on the following factors : (i) initial appearance of pottery types; (ii) relative time distribution of all types of excavated materials rather than only pottery and; (iii) period divisions based on the distribution of the total assemblage. The usefulness of the method cannot be overemphasised, though the present dearth of data on total assemblages does handicap any such approach. He, too, however, has avoided committing on absolute dates for his various phases. In the following discussions I would make use of this framework of phases and estimate their archaeological ages with the caution that the chronological estimates can only be tentative in the present state of knowledge.

We will hazard some absolute dates on the basis of Iranian affinities. Hissar is the key site for hinging the floating Baluchistan chronology to Iran, which is on a surer footing. Hissar IA—on both archaeological and radiocarbon dating evidence—has been placed to *ca.* 3700 B.C. and Hissar IB starts around 3500 B.C. (Dy 65). The Iranian dating, in its turn, depends upon the Mesopotamian contacts. Ubaid-Related-Horizon (late Ubaid, *ca.* 4000 B.C.) may cover Pisdeli in the north-west, then, from west to east, Siabad, Giyan, Sialk and Hissar. C^{14} dates are available for

Pisdeli culture (*ca.* 3800 B.C.) and Hasanlu VII (*ca.* 2150 B.C.). Pisdeli culture is contemporaneous to Hissar IA and Sialk III; and Hasanlu VII to Hissar IIIB approximately.

Details of the cultural assemblage were discussed in the previous chapter, here we will briefly refer to them while discussing chronological correlations. We will avoid detailed references too, as they have already appeared in Chapter 2.

PHASE C

The Rana Ghundai sequence we had discussed in the previous chapter. In Rana Ghundai (RG) I we noticed remains of a nomadic people, without housing remains, using handmade pottery, and flint and bone tools. Though Dales (D 65) included Rana Ghundai I and Sur Jangal I in his Phase C, yet their remains neither show settled village life nor any knowledge of wheel. Phase C by his definition is distinguished by the appearance of wheel, metal and settled villages.

We can identify this phase in Mundigak I in Afghanistan, Anjira II and other Quetta and Zhob sites. However, Mundigak I, is more akin to RG (Rana Ghundai) I in handmade pottery and semi-nomadic settlement. Wheelmade pottery and metal blades (*lame coudee*) appear in Mundigak I_2; and a few other objects in I_4. But only stone and bone tools are mainly used. Kili Ghul Mohammad II-III (Dales justifiably takes it as one period) period had seventeen wheelmade pottery types (out of the total 22). The distinctive pottery motifs are dot tipped hanging triangles and dot tipped six or eight-armed star (also in Hissar IC, Bakun AIII, Sialk III, 1-5). Decorated panel pattern in bichrome ware is introdced in this area for the first time in Mundigak I. Specialised surface treatment, basket marked ware, 'wet-ware' are other distinctive features. Also important is Togau A ware which occurs in Mundigak I and stylistically assigned to Anjira late Pd II and Sialk III, 4-5. Crude stone weights with handles (as in Mundigak I_5, Hissar IC) also occur. Parallel sided flint blades appear in Hissar I, Sialk III and Anjira II. Clay bull figurines (though available from surface finds from Zhob valley, none was recovered from excavations at Rana Ghundai) appear only in Mundigak. Bull figurines have now been reported from Siah II and Anjira II also by de Cardi (Dec 65). Alabaster vessels too are encountered in Mundigak I and Sialk III, 5-7.

On the basis of some motifs (e.g. black pendent triangles, reticulated band of streaked triangles) de Cardi (Dec 65) compared Anjira II to Sialk I. But at Sialk no wheel turned ware appears till Sialk III, which is more likely a comparison.

All these finds have, as we saw above, affinities mostly with Sialk III, 4-5 and Hissar IB and IC, so we may ascribe this Phase C to *ca.* 3300-3000 B. C. The Phase C sites are apparently confined to Afghanistan and north and central Baluchistan.

PHASE D

In this phase we see the emergence of settled villages in south Baluchistan and Indus region, accompanied by a multicoloured pottery. In northern Rajasthan (G 52) many sites, besides Kalibangan, of 'Sothi' (Pre-Harappan) ware were explored. In Bahawalpur region (Pak 64) and in Kot Diji (Kh 65) we see traces of permanent settlements. Possibly both polychrome and bichrome traditions, as also the humped bull, were diffusions from Afghanistan.

Dales (D 65) notes that the polychrome decoration is confined to northern uplands (e.g. Nal), whereas bichrome is concentrated in southern foothills and near the lower Indus plain (e.g. Amri). But still the shapes and some motifs are common between the two styles. Both in Amri and Nal animal and human figurines are absent. Only in Mundigak II clay female figurines occur. "Although interaction is to be seen at the earliest stages between the highland and the plains settlements, they seem to have sprung basically from different traditions. The origin of neither is yet certain. . . . ." (D 65), though for the polychrome tradition a western origin through Mundigak is more likely. The bichrome ware occurred in Mundigak I, 4-5 towards end of Phase C; its earliest occurrence is probably at Pirak.

Pirak, a site in Macchi plains at the eastern end of Bolan pass, yielded pottery which is marked by the use of two colours: black and a shade of brown on a cream or buff slip. The designs, as we noted earlier, include intricate lattice work and a predilection for diagonal motifs. Raikes has seen its affinities with Samarran levels, Nineveh III and Arpachiyah. The complete absence of curved or naturalistic motifs and predominance of diagonal motifs has parallels in the Samarran ware. The simultaneous occurrence of grey ware similar to that of Nineveh III and a developed bichrome ware like that of Nineveh II may suggest a Nineveh II-III date for Pirak. Casal (R 63) reports Pirak sherds from lower Amri levels, however. Raikes would place in at *ca.* 5000 B.C., which makes "any direct cultural evolution from Pirak to the known later chalcolithic wares of Baluchistan . . . . unlikely." Unfortunately the finds are from the surface only (also reported from Spina Ghundai, Quetta-Pishin Dist.) and include handmade and slow wheelmade pottery along with a wheelmade, heavy, plain grey ware. Notched blades are also distinctive. Laurel leaf arrow-heads were met with too. For placing the Pirak ware in *ca.* 5000 B. C. remote parallels with Mesopotamian sites have been alluded to. Pending further stratified evidence, a placement* younger than *ca.* 3500 B. C. would appear to meet the evidence (the occurrence of Pirak sherds in early Amri levels, laurel leaf points, and Nineveh II-III dating). But, it must be admitted, that such an early pocket of bichrome ware, south of Quetta, does provide a note of caution in deriving all these influences from the west. Casal (Prt. Comm.) would rather now place it in the beginning of Ist millenium B.C.

Piggot (Pi 50) and Gordon (Go 58) both had dated Nal cemetery later than the habitation. But polychrome decoration and ring based bowls, similar to Nal cemetery, occur in Mundigak III (Cas 61, Fig. 53, 55) and thus may be earlier than the upper levels of Areas D and F of the site. However, an identical bowl with a fish motif (Cas 61, Fig. 82, 295) is from Mundigak IV. Grey ware bowls painted with white loops provide a common link between Nal polychrome and Kechi Beg White-on-Dark slip Ware. The Nal like polychrome occurs at Anjira III along with Togau D sherds. Pd III at Anjira marked the use of roughly squared stones for foundations. At Siah in this phase was built a massive podium (Dec 65).

The occupation levels of Nal yielded cups with Mundigak IV affinities; one of the pots from Area F is identical in shape and decorations with Sadaat ware. Other traits also place it in Phase E (D 65).

Amri provides stratified evidence for chronological correlations. In Pd Ia itself we get, as noted earlier, handmade pottery, few wheel made sherds, scraps of copper, chert blades and, most important, Togau C sherds. The last trait provides the solid link with central and northern Baluchistan. Casal sees some resemblance between the bichrome of Amri and Pirak ware. Last phase, ID, heralds the introduction of humped bull painted motif in the Indus Valley. The bichrome ware appears in Amri II and Kot Diji Pre-Harappa levels.

Dales surmises a common origin of polychrome and bichrome tradition and a subsequent split as mentioned earlier. Both developed on different patterns. Nal developed a mixed farming and agricultural economy, while Amrians became sedentary agriculturists and finally were urbanished.

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*A recent C^{14} date from the late levels of Pirak is TF-861, 785 ± 190 B.C. only !

A painted grey ware was popular and flowered into several local varieties. In Quetta, Faiz Mohammad Grey ware, and at Anjira, Togau sherds are grey wares. The Quetta ware also is a trait of this Phase D.

The Pre-Harappan wares at Kot-Diji and Kalibangan have obvious affinities; though the assemblages cannot be called identical. This ware has variously been termed 'Sothi', 'Kalibangan I' and 'Kot Diji'.

Metallurgical progress is evidenced in Mundigak II-III in double volute pins, eyed needles, shafthole axes and adzes (similar to Sialk III). The fine parallel side blades become very popular. Laurel leaf shaped arrowheads are reported from Mundigak (from Pd IV onwards) and Kot Diji. Painted humped bull figurines and female figurines are also characteristic of this phase. It may be pointed out that the humped bull figurines appeas first in Mundigak III, before the Indus and Baluchistan areas.

Stamp seals with concentric geometric designs, in stone and bone, occur in this phase; but none in metal.

Fruit stands, grey ware, terracotta female figurines, copper adze with shafthole, stamp seals etc. help us place it in proximity to Hissar IIA and Sialk III. Thus we may ascribe Phase D to *ca.* 3000-2700 B. C.

PHASE E

This phase may mark the transitional stage from village to fortified settlements. We see remains of ramparts in Kot Diji; at Mundigak IV, there is a 'temple' and a 'palace'. A violent destruction ends Pd IV; so also at Kot Diji, a conflagration brings Pd I to an end. The black-on-red style becomes quite popular in this period; the multicolour styles die out or get transformed. The potter's marks appear first in Mundigak IV.

A preference for curvilinear and naturalistic motifs, instead of geometric ones, is evident in this phase as in Damb Sadaat III, Mundigak IV_1. The buckranium motif is a good link between Nindovari (Kulli levels), post-Cemetery Nal and Mundigak IV (Cas 61, Fig. 102, 485).

The humped bull figurines of clay become very popular in this period. Is it a recognition of the role of cattle power? We find them in Damb Sadaat III, Amri II, Kot Diji I and in post-cemetery levels of Nal; though they had appeared earlier in Mundigak. The zoomorphic motifs provide another link for correlating the various groups in this phase.

Female clay figurines are introduced in Damb Sadaat II. They have bent legs, huge breasts and elaborate necklaces. No heads have been found with these seated figurines. The Zhob type figurines occur in Damb Sadaat III. These have hollow fearful eyes, owl-like nose and phantom-like appearance, and are pedestalled. In South Baluchistan, the Kulli female figurines are the earliest.

The dating of the Kulli culture is quite enigmatic. While Piggot (Pi 50) and Gordon (Go 58) put the Harappan and Kulli together, Wheeler feels (W 62a) that the Kulli is antecedent and proto-Harappa. Nindovari yielded a non-polychrome ceramic of Nal type, bearing the buckranium motif, associated with the Kulli pottery. The Amri and Nal wares have many common motifs and shapes. Thus an approximate contemporaneity of Nal, Amri and Kulli is indicated.

The Makran coast has fortified posts of Harappan vintage (e.g. Sutkgen Dor, Sotka Koh and Balakot) and behind, in the Kej valley, are many Kulli sites. These Harappan fortifications could be for defence against Kulli settlements. But recent discoveries at Abu Dhabi (cf. Chapter 2) indicate that Kulli people may be the middle men in the Harappan and Mesopotamian trade. In that case the Harappan fortifications may only be for 'policing' the trade of Harappan goods run by the Kulli people. This would mean, at least, part contemporaneity of the two.

The clay house models or compartmented boxes have been used as dating evidence. It will be pertinent to digress here to evaluate their dating evidence. An exhaustive catalogue of these vases has been published by Durrani (Du 64).

These vases are divisible into three groups on the basis of decoration. It is significant to note that the compartmented vessels have only curvilinear and geometric designs (Group I). But they are confined to Indus and Baluchistan only, no such vessels are known outside the Indo-Pak borders. Now Umm-an-Nar in Persian Gulf has yielded such vessels from Cairn II (D 65). This site has yielded other Kulli materials too, thereby indicating trade carried by the Kulli people. In this light Piggot's suggestion (Pi 50) that these compartmented vessels were exported from Makran to the west as part of unguent trade becomes significant.

But the vases with architectural scenes (Group II) or naturalistic or mythological motifs (Group III) are conspicuous by their absence from Indus and Baluchistan area. Even between the Indus and Baluchistan vases there are differences: from the former area they are square, while the ones from the latter regions are circular. The Indus examples have a different material and are lidded.

Groupwise Distribution of Vases

Group	Indus	Baluchistan	S.E. Iran	Elam and Luristan	Mesopotamia	Syria
I	2	4	1	6	5	2
II	nil	nil	2	1 (Susa)	5	1
III	nil	nil	nil	nil	6	6

Thus we see that in shape, material and even idea these vases are quite heterogenous and should not be lumped together. The significance of these objects for specifically Harappan dating will be discussed below.

The compartmented metal seals appear in Mundigak IV and Nal (post-cemetery levels).

Lapis lazuli occurs in Damb Sadaat II, Nal (habitation), Kulli and Mehi. Copper pins with voluted heads are too diffused to be of any dating value. So also hollow clay balls with painted or incised designs which are ubiquitous in this phase.

Two other parallels between Mundigak IV and Indus Valley are : terracotta mouse traps (Cas 61, Fig. 84, 314; M 37-38, Pl. LIV, 16, 17, 2022) and; a stone head, from Mundigak IV_3 which is very much like the Indus examples found in HR Area, "South Lane", House A_1. The resemblances in the head ribbon, shaved upper lip, beard and treatment of ears is striking between the two.

The compartmented stamp seals may help connect Phase D to Hissar IIB. The clay figurines with fan-like arms in Mundigak IV_3 have parallels in Bakun A. The zoomorphic painting style on pottery has affinity with Susa D and Umm-an-Nar. Compartmented cups with incised designs have lower Mesopotamian similarities of Early Dynastic date. These western parallels justify an assignment of this phase to *ca.* 2700-2400 B. C.

The antecedence of the west in most of the cultural traits (if early Pirak is an enigma) may indicate a west to east diffusion. Thus for the same traits little earlier dates in Iran than Afghanistan, and relatively earlier dates in Mundigak than Baluchistan sites should be expected. A trait appearing much earlier in Mesopotamia, may thus be of relatively late date in Baluchistan. But objects of the Indus trade, found in Mesopotamia, will indicate contemporaneity.

A. (ii) *Harappan Chronology*

The Harappan chronology with a datebracket of *cv.* 2500-1500 B. C. as propounded by Wheeler (W 62a) was almost universally accepted till 1962. In fact, whenever a Harappan site was found this millennium-bracket was fixed on it. For long, the Harappa culture and the millennium long spread had become inseparable.

However, the improbability of a thousand year long stagnation was bound to create doubts. From 1961 onwards radiocarbon dates accelerated this rethinking and as we will see below, a shorter date-bracket for the Harappans has a much stronger case than the earlier postulate.

We will reappraise the Harappan chronology in its 'historical' perspective. The archaeological evidence for dating this culture to *ca.* 2500-1500 B. C. will be examined first; the C^{14} dates will be analysed later.

Fairservis in his stimulating though speculative paper (Fa 61) tried to analyse the character and genesis of Harappa culture. Commenting upon the changelessness of the Harappa culture he says, "If we compare religion-oriented civilisations such as classic Maya, the Egyptian, and the Harappan, the phenomenon of generally static trait style, in time and space, stands out as an important characteristic. This static quality appears to reflect a stable productive economy and a paucity of interaction with other cultures outside the culture. . . the *status quo* has favourable advantages."

But he was not willing to ascribe a thousand years to this stagnation. "It is doubtful that the depth of deposit here represents a great span of time. Flood caused destruction and rebuilding could have taken place in 25 years as well as in 250. In this regard, an examination of Harappan levels at numerous village sites in Sind reveals a surprisingly narrow band of occupation as compared to earlier occupations. . . . (at) sites such as Kot Diji, Dabar Kot and Amri. . . . I am not convinced that the Harappan of Sind at least represents an occupation by that culture of anything close to the thousand year span which is accepted at present. . . . I would expect that it was nearer 500 years" (Fa 61).

To me, too, the archaeological evidence did not seem to warrant a millennium long time spread for the Harappa culture. Emboldened by the C^{14} dates measured by us for some Harappan sites, I proposed (Ag 64) a date-bracket of *ca.* 2300-1750 B. C. The traditional 1000 year bracket was frontally criticised in this paper. The climate was congenial now. Lal (Lal 62-63) on receiving the first Kalibangan C^{14} dates was also rethinking in terms of an earlier end of the Harappa culture. But C^{14} dates we will discuss later. First, we will examine below the archaeological premise for a 1000 year span.

Mode (Mod 61) has mentioned many general resemblances between the Harappan artifacts and motifs and their western counterparts. He has postulated relations of the Harappans as far west a

Crete. However, the motifs quoted by him are generally too amorphous to arrive at concrete conclusions. Nor have any stratigraphical levels been mentioned. Thus belittling the dating value of his work. However, it has its significance in tracing the diffusion of art motifs.

For critically examining the dating evidence we will use the arguments and the approach already discussed elsewhere by me (Ag '66a). In this examination the following considerations have been taken into account.

Firstly, the bulk of the archaeological evidence comes from the older excavations when scientific stratigraphy was not developed. For instance, Langdon (Lan 31) once found an Indus type seal from pre-Sargonic levels but in association with a Sargonic pommel! These pitfalls of bench level stratigraphy put a severe limitation on the available evidence.

Secondly, objects with even vague Indian affinities have generally been lumped together for dating the Harappa culture. Now, with the discovery of a well-spread Pre-Harappa Culture in Sind, Punjab and Rajasthan it is likely that some contacts with the west Asia might belong to this period. This necessitates that we use only artifacts of definitely Harappan character, discovered in the west Asian datable contexts, for dating. Conversely, exotic artifacts used for dating, should belong to definite Harappan levels.

The available archaeological evidence has been discussed below chronologically under pre-Sargonid, Sargonid and Isin-Larsa, and post-Larsa periods.

Pre-Sargonid Evidence

(a) Seals*: Gadd No. 1 is an unstratified squarish seal with only a buttonback to make it Indus-type. It has three pre-Sargonic signs over a bull-like animal. Gadd himself admitted that "it is always hazardous to date an object solely by the epigraphy of a cuneiform inscription, especially in the case of seals" (Gad 32). This seal obviously has no dating value.

Gadd No. 16 is a circular steatite seal with Indus-script and bull found from the filling of the tomb-shaft originally ascribed to the II Dynasty of Ur by Woolley. Frankfort (Fra 39) however ascribed the II Dynasty itself to the Akkadian period. Woolley (Wo 55) later wrote: "it was difficult to be sure whether the object (the seal) in question belonged to the grave or must be associated with the later rubbish introduced at the time of the disturbance in which case it would be of Sargonid date." So finally this seal has become an evidence for contacts in Akkadian times only.

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* Gadd seal numbers are quoted as mentioned in his classic paper, "Seals of Ancient Indian Style found at Ur" (Gad 32) and Wheeler seal numbers refer to the ones given by him in his "Indus Civilisation" (W 62a).

Wheeler No. 4 was included in the ambiguous category of "Sargonic or pre-Sargonic" by Gadd and has been discussed below.

(b) Humped Bull Motif: Humped bulls appear as early as *ca.* 3100 B. C. on the "Scarlet Ware" of Diyala region, as also in Mundigak I_3. There are many examples of such motifs in West Asia datable to the close of the fourth millennium B.C. Nothing is known about the distribution of the humped bull in pre-Harappan times. Unless the craftsmanship has definite Harappan affinities, such similarities can be of no dating value. A stone bowl, datable to *ca.* 2700-2500 B.C., from Mesopotamia has a mythological scene which Mallowan (Mal 61) felt was Indian. There is nothing characteristically Indian about it, much less Harappan. As a dating evidence for the Harappa culture it has hardly any value. The bull motif occurs earlier in Mundigak I and other Baluch sites than in the Harappa culture.

(c) Stone-Vases: In discussing the chronology of the Pre-Harappan cultures we had earlier referred to the typology and distribution of stone vases. Mohenjodaro yielded two specimens:

(1) from early levels, House V, Room No. 53 in DK area, depth 28.1′ (M 37-38, Pl. CXLII). It is a fragment with matt-work like decoration.

(2) from House III, Room No. 76, 5′ depth, late phase (Mar 31, Pl. CXXXI). Decoration consists of incised hatched triangles and chevrons.

In comparing these examples with the west, it is important to note that "compartmented vessels are confined to Baluchistan and Indus, no such vessel is known outside the Indo-Pak borders" (Du 64). Even between Baluchistan and Indus examples there are differences. The former are made of steatite, and the latter of slate. In shape also from the former site they are circular, whereas, from the latter one, they are square and lidded.

The matt-work design bearing fragment from Mohenjodaro early levels has close similarities with Kish and Susa D which may now be dated (Mal 61) to *ca.* 2500 B. C. Though with the discovery of such vessels in Umm-an-Nar (D 65), and Piggot's original suggestion that they were used for unguent trade from Makran, new possibilities emerge. Occurrence of the Kulli pottery and compartmented vessels in Persian Gulf indicates trade carried on by the Kulli people as middlemen between the Harappans and Mesopotamians. The Harappan ports like Suktagen Dor, Sotka Koh, Balakot on Makran coast and a number of Kulli sites in Kej valley become significant, as noted earlier.

(d) Multiple Swastika Motif: Ascribing an Akkadian period to the foreign contacts of Lothal, Rao (Rao 63) points to Tell Brak parallels for Lothal seals decorated with Swastika motif in multiple lines. In Tell Brak such motifs occur on cushion amulets with undersides decorated with animal motifs but are datable to *ca.* 3200 B. C. (Mal 47). On this evidence we will have to ascribe Lothal to the fourth millennium B.C.

Thus we see that the evidence, as it is available today, does not allow the anterior date limit of the Harappa culture to extend to the pre-Sargonid times.

Sargonid and Isin Larsa Evidence

(a) Seals : Gadd No. 16 as shown above may belong to the Sargonid period only.

Gadd No. 15 is a circular steatite seal with a crowded "inscription." The symbol on the left top is not a flower but a scorpion. The legend does not look like Indus script. The seal was discovered in association with a Sargonic assemblage. Even if we accept it as an Indus seal, it is of the Akkadian period only.

Wheeler No. 4 is unmistakably an Indus type square seal from Kish which "should be pre-Sargonic, but it was found with a stone pommel bearing an inscription clearly not earlier than Sargon of Agade. Both objects, therefore, may have fallen from above" (Lan 31). This also indicates a Sargonic date only.

Wheeler No. 5 is a cylinder seal of glazed steatite depicting an elephant, rhinoceros and crocodile. The realistic style is typically Harappan (Fra 39). As these animals are foreign to Babylonia, they could only be depicted by an artist who had seen them closely. This seal was found in Tell Asmar in an Akkadian context.

Wheeler No. 6 is an alabaster seal with concentric squares found in Tell Asmar from Akkadian levels.

Wheeler No. 7 is a square terracotta seal with concentric squares from Tepe Gawra VI, datable to the later part of the Early Dynastic or the beginning of Sargonid age (Spe 35).

Wheeler No. 8 is a square steatite seal with Harappan legend from Kish. Mackay (M 25) ascribed it vaguely to an "early Sumerian date." As it seems to have lain below the pavement of Samsu-iluna, it cannot be later than *ca.* 1700 B. C.

On two Harappan seals (one each from Harappa and Chanhudaro) eagles with spread wings are depicted. Such motifs occur in Susa in *ca.* 2400 B. C. Spread eagles as images of Im-Dugud (*ca.* 2200 B. C.) as also copper inlays in the same form (*ca.* 2100 B. C.) appear in Tell Brak (Mal 47).

A steatite seal with an embossed back and a pair of gazelles on the face has been reported by Rao (Rao 63) from Lothal. Unfortunately, it is a surface find. It is a 'Persian Gulf Seal' type as found in Barbar and Ras-al-Qala. Comparable circular seals from Failaka, near Kuwait, have been assigned by Bibby (Gl 60) to the Sargonid period. Lothal being a Harappa culture site, one can surmise its import possibly during the heyday of this site.

Wheeler No. 9 is a seal with Harappan legend from Telloh (Ga 32) ascribed to Larsa age.

Gadd No. 6 is a cylinder seal, depicting a humped bull, a human figure, snakes and scorpion from a Larsa tomb. Stylistically it has been ascribed to Harappan craftsmanship.

Wheeler No. 12 is a cylinder seal fragment from Hama bearing a large eyed bull (*ca.* 2000-1750 B. C.) akin to Kulli. Buchann goes to the extent of saying, "One cylinder seal, with Indus type designs came. . . . as a find along with many late Akkadian and few post-Akkadian seals. None of the other Indus imports had a find spot *certainly* earlier than this" (Buc 67).

(b) Beads : Etched carnelian beads with figures of eight and "eyes" (Type I) are identical both in Harappan and Mesopotamian sites. From the Tell Asmar (Fra 33a) houses of Sargonid period such beads, in association with other evidence of the Harappan contacts, have been reported. Without claiming them to be Harappan imports, these beads nevertheless point towards a common trade during Sargonid times.

The disc bead type with axial tube is reported from Early-Dynastic to Akkadian times and Troy IIg thus covering a period from *ca.* 2500-2300 B. C. (W 62a). Silver disc beads from Sargonid levels of Tell Asmar are also identical (Fra 33).

Kidney shaped bone inlays from Sargonid Tell Asmar bear unmistakable affinity with the Harappan shell inlays copying chank cut sections.

Wheeler, on the basis of the fluctuations of lapis lazuli trade, suggests "that the bulk of the known strata of the Harappa sites may equate rather with the Akkadian and post-Akkadian periods than with any considerable portion of the Early-Dynastic" (W 62a).

Post Larsa Evidence

(a) Seal: Gadd No. 12 seal is responsible for bringing down the upper limit of Harappa culture to *ca.* 1500 B.C. Except for a button back on it there is nothing Harappan about it. It depicts a water-carrier with his yoke and two skins. This seal was found at Ur "from upper rubbish Kassite(?) level" and so is not of much datable value.

(b) Faience Bead : An unstratified Harappan segmented faience bead on spectroscopic examination (Stn 49) has been found to be identical with a Middle Minoan III bead. On the basis of its relative popularity in Egypt under the XVIII Dynasty, it has been dated to *ca.* 1600 B. C. On the other hand, segmented glazed steatite beads occur *ca.* 3200 B. C. in Khabur Valley. This shows the complexity of the problems of the origin and distribution of such beads.

(c) Metal Objects: Certain dates have been attributed to the metal objects (cf. Chapter 6) supposedly associated with the end of Harappa Culture. Their west Asiatic counterparts occur in so diverse chronological horizons that their dating importance is doubtful "until local values are settled independently" (Pi 47-48).

The contexts of the finds of these metal objects are too indefinite to reach an agreed chronology. The issue is further complicated by the various invasions and migrations to which the north-west India was subjected. Anyway, two broad folk-migrations can be discerned to which most of these objects may have belonged. "It is in this context of folk-migrations around 2000 B.C. and the subsequent few centuries, that we can set the end of the Baluchi villages and the Harappa cities, but there is evidence that second wave of conquest or colonisation from the West left traces in Baluchistan nearly a thousand years later" (Pi 50). For example, the Shahi Tump cemetery might belong to the earlier wave datable to *ca.* 1800 B. C. and the Cairn-burials of *ca.* 1100-1000 B. C. to the second wave.

Thus we see that the only reliable datable contacts are confined to Sargonid and Isin-Larsa levels and in no way permit us to push the beginning of Harappa culture beyond *ca.* 2350 B. C.

Buchann (Buc 67) has categorically stated, "The Mesopotamian evidence, therefore does not require a date for the mature Indus civilisation much, if at all, before the 23rd Century B.C.. . . . It would be surprising if it (the mature phase-DPA) lasted more than 300 years. It is therefore possible that the mature Indus phase ended about 2000 B.C."

The millennium long spread and a complete monotony in Harappa culture looked irreconcilable to many, especially to people coming from other disciplines, who were not conditioned by archaeological axioms. Raikes (R 64) said, "This stagnation, for which the case rests on an attested uniformity of material culture coupled with an unproved duration, is hard to believe. It is as if the material culture of France had remained unchanged in its minutae from the time of Charlemagne to the French Revolution. . . .Its acceptance really depends on acceptance of the estimates of duration. If the evidence. . . . be interpreted in terms of a shorter duration, we would no longer have to believe simultaneously in a stagnation of ideas and in creative vigour. . . . The whole picture of Mohenjodaro would become more creditable if it could be shown that occupation of the site was for a much shorter period."

Raikes is a hydrologist: his doubts originated in the inexplicable silt deposits at Mohenjodaro. "Taking the archaeologists' estimate of 1000 years duration, a very strange fact emerges: during 1000 years of occupation of the city, 30 feet of silt were deposited; during the subsequent nearly 3500 years, no further silt has been deposited. It is even possible that there has been some lowering by erosion, of the flood plain during this second much longer period." (R 64).

Raikes elaborated the geomorphological causes for the destruction of Mohenjodaro. The details of his theory will be discussed in Chapter 7.

A. (iii) *Chronology of Other Chalcolithic Cultures*

Before we pass on to the other Chalcolithic cultures, we may note briefly the immediately post-Harappan cultures. The devolution of the Harappa culture in Saurashtra has already been discussed in Chapter 2.

The Cemetery H, 120 yards north-east of Cemetery R37, at Harappa had two phases. In the earlier (Stratum II) phase extended inhumations were in vogue, whereas in the later phase (Stratum I) pot burials of excarnated remains were in use. Both Childe and Wheeler sought to associate them with the Aryans and the destruction of the Harappans. But Lal (Lal 54-55) has pointed out that a débris of 7′-9′ intervenes between the cemeteries R37 and H. In habitation area too a débris layer of 3′ separates the Cemetery H from the Harappan levels. Thus we can place the Cemetery H only much after the end of the Harappans.

In recent years, several sites (Fig. 2) of Jorwe-Malwa and Banas cultures have been excavated. The pottery and other associated objects have now been studied in greater detail and their western affinities determined. Though it may be stated at the outset that these links are often vague and so tenuous that they can only indicate the directions of diffusionary impulses rather than the actual datable contacts.

The west Asiatic affinities of the Chalcolithic pottery and other objects were given in detail by Sankalia (S 63). Below, I will discuss these parallels under two categories: the pottery and the other objects.

Affinities in Pottery

The channel spouted bowls appear in Pd III at Navdatoli. Since more than 100 spouts have been discovered, it can safely be inferred that they were a local manufacture, rather than an import. The channel is open, with a solitary exception of a spout with circular outlet. Designs are few, comprised of cross-hatched lozenges connected in series. Occasionally inside the bowl grotesque human figures also occur, recalling the motifs on the Cemetery H pots.

In India, spouted vessels are reported from Daimabad, Gilund, Rajar Dhibi, Chirand and Oriyup (Bihar). Though, except for a metal type from Khurdi, all other parallels are distant. Sarma (Sar 67-68) has drawn attention also to the so-called channelled bowl from Patapadu. But this bowl is only lipped, and not spouted. Lipped bowls are common in the P. G. Ware and N. B. P. levels in the north too and are too generalised shapes to be of any datable value.

"To a lesser degree one may compare similar spouted vessels from Sialk B, Hissar III A-C and vessels from Luristan, though the latter are highly decorative. In particular, the design on the spout of Sialk B is identical with the one of the three designs on the Navadatoli vessels" (S 63). The close similarities of these vessels are with Sialk B and Giyan I, both ascribable to *ca.* 1000-800 B.C. Thapar (Th 65) has pointed out that whereas iron and grey ware (of Hissar III-Anau III complex) are associated in Necropole B and Giyan I, both these traits are completely absent in the Indian Chalcolithic cultures. Gupta (Gu 65), on the other hand, said, "the channel spouted vases from Sialk have not only considerably longer channels but in addition have curved handles. I feel that we cannot isolate this feature of the spout for purposes of comparison." He therefore pleads for an independent origin of these cultures.

Sankalia is conscious of the late dates of these western parallels. To explain the paradox he opines "that Navdatoli vessel is not a direct copy of any one vessel from any particular site in Iran, but an adaptation of the idea which was current in Iran and Western Asia as far as Crete" (S 63).

If the 'tea pot' type is included in the category of channel spouted vessels, then one can push back their antiquity. Gordon (Go 5F) has traced the origin and spread of the 'tea pot' type and classified it in three groups (Types I, II and III) on the basis of the ratio of open to enclosed (tubular) portions of the spouts. He places them in Crete *ca.* 2400-2100 B.C.; in Greece *ca.* 2000-1800 B. C.; in Asia minor and Syria *ca.* 2100-1700 B. C.; and in Palestine *ca.* 1850-1700 B.C. In Giyan they were introduced probably around 1800 B. C. But the type close to the Navdatoli specimens is not of this 'tea pot' type, but an open-mouthed bowl outside Gordon's Types I to III.

So finally we are left with Sialk B and Giyan I comparison only. As the dating of Sialk B is very pertinent to our discussion, we would digress a bit here to determine its currently accepted dates.

Schaeffer (Sch 48) had pleaded for earlier dates of Sialk B than those proposed by Ghirshman (Gi 38-39). In a recent review Ghirshman (Gi 64) has refuted Schaeffer citing some Transcaucasian parallels of black incised pottery which has been firmly dated to the extreme end of second millennium. This type of pottery occurs in Cemetery A, therefore B cannot be dated to the second millennium B.C., as it is later than the former. He does not attach much importance to the discovery of a stray scarab with the name of Seti I (*ca.* 1400 B.C.) but gives more importance to a cylinder seal from Cemetery B which has affinities with the Assyrian seal of *ca.* 900 B.C. Finally, the fact that the megalithic tombs, which constitute the most noteworthy feature of Cemetery B, did not appear on the Plateau before the first millennium B. C., militates against an early dating of Sialk B. "Thus we abide by our original dating of them to the tenth or ninth, or even perhaps to the early eighth century—which is in accordance with the views of Przeworski, Akurgal and Diakanov" (Gi 64). Similar levels in Hasanlu in Azerbaijan have been dated to 812±130 B. C. by C^{14} method.

The pedestalled bowls occurred at Navdatoli from the very first phase. Normally their stem is solid and bases flattish, but there are instances of hollow stems also. Now from Rangpur Pd III (Rao 63) also stemmed bowls have been reported. Rao, however, holds that these stemmed bowls have devolved from the Harappan dishes-on-stand in three stages. At Rangpur such bowls occur both in L.R. Ware and coarse grey ware. A hollow stemmed bowl has also been reported from Kalibangan Pd I (IAR 63-64). From Ahar also a hollow stemmed bowl in coarse grey ware has been discovered. In Jhukar period, such bowls have been met with at Chanhudaro too.

"All these four or five types of goblet may be generally compared with the respective forms from Sialk, Giyan and Hissar II, though it must be pointed out that in these Eastern Iranian sites, the stems are rather low and usually hollow. However, at Hissar, particularly Hissar III A, we do find bowls with long, solid stems though the bowl forms and designs compare more favourably with those of IB and IIA" (S 63). But as Sialk I-III and Hissar I-II are too early for Ahar and Navdatoli, Sankalia has postulated only a general connection with these Iranian sites.

Thapar (Th 65) has noted affinity between the round bowls (decorated with hollow circles filled with dots) and examples from Carchemish in the 'champagne grave strata' ascribable to the early Hittite period.

I also noted a few parallels between Mundigak (Cas 61) and Navdatoli pottery. Navdatoli bowls (S 63, Fig. 8A) are comparable with Mundigak examples (Cas 61, Fig. 66, 190-192) and the long stemmed bowls (Cas 61, Fig, 8e) with the Mundigak concave sided bowls (Cas 61, Fig. 65). Both these parallels are dated to Mundigak IV (*ca.* 2200 B.C.). There is a very close resemblance between the bowls (S 63, Fig. 9 and Cas 61, Fig. 58, 107a) from the two sites. Even the panel of solidly filled alternate triangles is identical in the two cases. The Mundigak example comes from Pd III (*ca.* 2800 B.C.).

The theriomorphic vessels have been reported from a large number of sites in the west. In India, Chandoli and Nevasa have also yielded examples of this class. But it is to be noted that most of the western examples have a vertical opening, whereas the Indian specimens have it on the side (in the position of mouth). However a comparable example from Sialk Necropole B too has a side opening. From Mundigak IV$_{1,3}$ (Cas 61, Pl.XXXVII) also a theriomorphic vessel is reported. A three (?) legged bowl from Chandoli too is comparable with Giyan examples.

Sankalia (S 55) had compared the linked dancing figures' design with that of Sialk and Chagar Bazar etc. Linked human figures, in a stylised form occur in Togau Ware (Stage A) too.

The spiral motif is unique in Navdatoli. It does not occur either in west Asia or anywhere else in India (S 63). However, the pot hook spiral is found in Londo Ware, Amri, Harappa, Prakash (Th 67, Fig. 10, 6) and Tekwada (IAR 56-57).

A globular vessel with long narrow neck and a broad dish like rim as also the 'Kuja shaped' vessels have no exact western parallels, though there seems to be an Iranian influence (S 63). Far resemblance in general shape, examples from Mundigak IV could be cited (Cas 61, Fig. 71, 217-219).

Parallels in the Other Objects

The mid-ribbed blade fragment from Navdatoli and the antennae hilted dagger from Chandoli may be compared with the western examples (see, however, Chapter 6).

More interesting is the identity of several designs of spindle whorls from Ahar and Troy. From Nagda also whorls with incised designs were recovered, though Sankalia thought they were unique in Ahar only.

The earliest occurrence at Navdatoli of lentil and linseed may indicate a new element in the dietary. In Hacilar, lentil goes back to *ca.* 6600 B. C. These cereals and seeds are not mentioned in Vedic literature.

Gupta (Gu 67-68) has recently reviewed the views of Zadneprovsky and Shchatenko on the relationship of the Indian and Farghana Valley Chalcolithic cultures. Zadneprovsky (Gu 67-68) held that the Chust culture of Farghana Valley and the Malwa culture sites had close contacts. Shchatenko (Gu 67-68), on the other hand, considers the Indian Chalcolithic cultures to be purely indigenous. The affinities with the Chust culture (type site, Dulvergine) have been based upon comparisons of everted rim bowls, high-necked vessels, carinated and spouted bowls. Common geometric motifs and a human figure are also cited. Gupta says that the general similarities in non-specialised items is due to akin agropastoral economies.

More important are the differences in the burial customs. In India multiple pot burial and extended inhumation was in vogue, whereas in Farghana Valley crouched burials held the sway. Dulvergine is fortified, whereas all the Indian counterparts are open villages. The C^{14} dates for Dulvergine (2720±120 B. P. and 3050 ±120 B. P.) are late. Thus we see that the Chust culture too does not provide datable evidence for the Chalcolithic cultures of India.

The brief survey, attempted above, brings out the difficulties of using such data for archaeological dating. Mostly the parallels are of a general nature and too widely scattered in time and space. There are still big blanks—both temporal and spatial. Sialk B and other comparable levels do offer closer parallels but are much later. Moreover, it is difficult to assume the borrowing of the pottery only and not an utile metal-like iron. Nearer home, Mundigak also offers some comparable shapes and designs datable to 2800-2000 B. C. (Pd III and IV). But this evidence too is not conclusive.

Kayatha with its unique pottery, terracotta bulls and developed copper technology sounds a note of caution for the diffusionists who trace everything from west Asia. The Kayatha culture, in my view, is a strong point in favour of the probability of independent origins of some of the Chalcolithic cultures.

Thus in the absence of definite archaeological evidence we have to depend almost completely on the C^{14} -method, for dating the Chalcolithic cultures.

Relative Chronology of Chalcolithic Cultures

The painted B-&-R Ware provides a common link amongst Rangpur (Pd II onwards), Lothal A and B, Ahar Ia, Navdatoli I, Nagda I, Eran IIC and III. Hatched triangles, zigzag lines etc. are common in Rangpur and Navdatoli. Thus Navdatoli III is comparable to Rangpur IIC and III.

Gilund has the painted B-&-R Ware throughout its occupation, whereas it is confined to Navdatoli I. Besides, the cream slipped ware bearing dancing figure, spotted animals etc. occurs in the uppermost levels of Gilund, but at Navdatoli it is restricted to early phase only. Thus Banas culture at Gilund could be earlier than Navdatoli. However, the cream slipped ware is found from Ahar Ia itself.

The Malwa Ware has a longer span even in Navdatoli where it occurs from Phases I to IV; it also occurs in Nagda I, Bahal IB, Daimabad Phase II, Chandoli I, Prakash IA.

The Jorwe Ware appears in Prakash IB, Navdatoli Phases III-IV, Bahal IB, Nevasa III, Chandoli I, Jorwe I, and Ahar IB and Daimabad III. Stratigraphically Jorwe Ware was found to succeed Malwa Ware for the first time in Prakash; this was confirmed subsequently at Daimabad, Bahal and Navdatoli.

The coarse B-&-R Ware as also the inferior cream-slipped ware make Chandoli posterior to Navdatoli. Moreover at Chandoli, the Jorwe Ware (37% of total) dominates over the Malwa Ware. Absence of the cream slipped ware at Nevasa indicates a later date for it than Chandoli. Thus "Chandoli may be taken to be later than earlier phases of Navdatoli and possibly a little earlier than Nevasa" (DAn 65).

The L.R. Ware also provides a link amongst several Chalcolithic sites. It is found in Rangpur IIB and C, Prabhas IIA, Navdatoli IV, Prakash IB, Ahar IC, Eran, Bahal IB.

On this showing, the Banas culture is the earliest of all the Chalcolithic cultures. Navdatoli comes next, because of the early occurrence of the B-&-R and the cream slipped wares and late occurrence of the L. R. Ware followed closely by Nagda, Eran, Rangpur IIB, Prakash, Jorwe, Chandoli and Nevasa, which comes last in this sequence. Though Prakash yields the Malwa Ware from the very beginning, yet the presence of L. R. Ware in IA tends to place it later in the sequence.

A. (iv) *P. G. Ware Chronology*

Lal's (Lal 54-55) Hastinapur excavations for the first time put the P. G. Ware in a stratified sequence. At Hastinapur the O. C. Ware occurs in Pd I, the P. G. Ware in Pd II and the N. B. P. in Pd III, the last period beginning *ca.* 600 B. C.

"A heavy flood in the Ganga washed away a part of the settlement of Pd II and that the third occupation came into being after an appreciable lapse of time. During this interval the people had completely given up the P. G. Ware and had developed instead the N. B. P. Ware. The plain grey ware also had degenerated to a considerable extent and several new forms had come into being. Mud-bricks were replaced by burnt-bricks, iron had come into use and a system of coinage introduced. All this change would have certainly required a couple of centuries." Thus Lal dated the end of the P. G. Ware at Hastinapur to *ca.* 800 B. C. For the 7′ of habitational débris of Pd II he assigned another three centuries thus placing the beginning of the P. G. Ware *ca.* 1100 B.C., with a probable margin on the earlier side.

As we will see below, in dating both P. G. and N. B. P. wares, the associated red ware shapes are equally important. In fact, they are more sensitive to time changes, than the P. G. and N. B. P. Wares. Both N. B. P. and P. G. Wares were deluxe wares. At Atranjikhera, the P. G. Ware is only 3-10%; no quantitative distribution is available from Hastinapur. The author has been careful to record (Lal 54-55) that there were 101 sherds of the N.B.P. in Pd III deposit. Admittedly this is so meagre for two seasons work and emphasises the deluxe nature of the ware.

Lal's chronology had a bias towards older dating, therefore he gave longer durations to each gap between the consecutive periods. To quote Gordon (Go 57), ". . . Pd IV which contains a definite Gupta terracotta and moreover, nothing that can be dated from 50 B.C. to A.D. 400. Then there is a break—the town was burnt down. But why one of a hundred years ? Fifty would be ample. It is doubtful whether Pd III lasted more than 250 years, as there is nothing to account for a longer duration, the dating of the N. B. P. prior to 400 B. C. being highly debatable, and the terracotta figures all being 2nd and late 3rd Century B. C. Before Pd III there is again a break following on the settlement in part washed away by the Ganges. Here, because the dating of the painted grey ware back to 1100 B. C. fits a theory of Vedic origins, ao unnecessarily long gap of 200 years is postulated when 100 at the outside would suffice, N.B.P. being clearly an extension of P. G. Ware with a new fashion of surface treatment. Lal's dates for the beginnings of Pd II and III are 1100 and 580 B.C., but there is a good case, if not better, for substituting 700 and 350 B. C."

Wheeler (W 59) also opined, "If the initial date of the N. B. P. in the Ganges region be placed somewhere in the 5th Century B.C.. . . . the beginning of the P. G. Ware might be ascribed to the 8th Century B.C."

We will examine Lal's dating of the P. G. Ware further which was based on the following factors:

(i) Correlations of Mahabharata episodes with the desertion of Hastinapur;
(ii) Absence of iron in the P. G. Ware levels;
(iii) Gap between the P. G. Ware and the N. B. P.;
(iv) An early dating of the N. B. P.

We will first discuss the points (ii) and (iii); the dating of the N. B. P. (iv) will be dealt with separately below. Point (i) is out of our scope to examine.

The excavations at Alamgirpur and Atranjikhera have now yielded iron from the P. G. Ware levels. Even from Ḥastinapur, the excavator was vigilant enough to report iron slag like material. The P. G. Ware is now unanimously accepted as an iron using culture.

There is a definite gap between the Harappan culture and the P. G. Ware at all the sites so far studied. In Bikaner region the two cultures are never found on the same site (G 52). The B-&-R Ware is still an enigmatic problem. But the isolation of a distinct B-&-R Ware deposit, devoid of and preceding P. G. Ware, is an important contribution of Atranjikhera excavations.

At Hastinapur, a big flood (though there are differences about its magnitude) coincides with the desertion of the site. Lal equated this event with the Puranic reference, "when the city Hastinapur is carried away by the Ganga, Nichaksu will abandon it and will dwell in Kausambi". After the flood gap, the N. B. P. occupation starts.

The evidence, mainly from Atranjikhera and Sravasti, points towards a continuity between the P. G. Ware and N. B. P. deposits and the ceramic traditions. Sravasti yielded a few sherds of the P. G. Ware from the earliest levels of the N. B. P. period. Some of the bowls and dishes have identity of shapes.

Two other crucial factors enter into discussion: (i) the respective epicentres and distribution zones of P. G. and N. B. P.

Wares and; (ii) the associated red ware types of the two (P. G. and N. B. P. wares).

The distribution (Fig. 3) of the two wares would show: the P.G. Ware extends in a rhomb with points at Lakhiyopir in Sind, Gilund, Kannauj and Rupar; the N. B. P., on the other hand, is spread (Fig. 3) from Brahmapuri in the south to Rupar in the north, from Prabhas Patan in the west to Bangarh and Chandraketugarh in the east. Unfortunately, most of the excavation reports are unpublished; wherever published, the frequencies of the P. G. and N. B. P. wares in the total ceramic assemblages are not given. Still, probably it can be emphasised on the basis of available evidence [Sec. II A(v)] that the P. G. Ware has its epicentre as also the concentration zone in western U. P., and east Punjab; whereas the N. B. P. has an eastern origin, probably in Bihar. As we will note later, the utilisation of the Bihar iron ores and the spread of the N. B. P. may too be connected in some way. In this

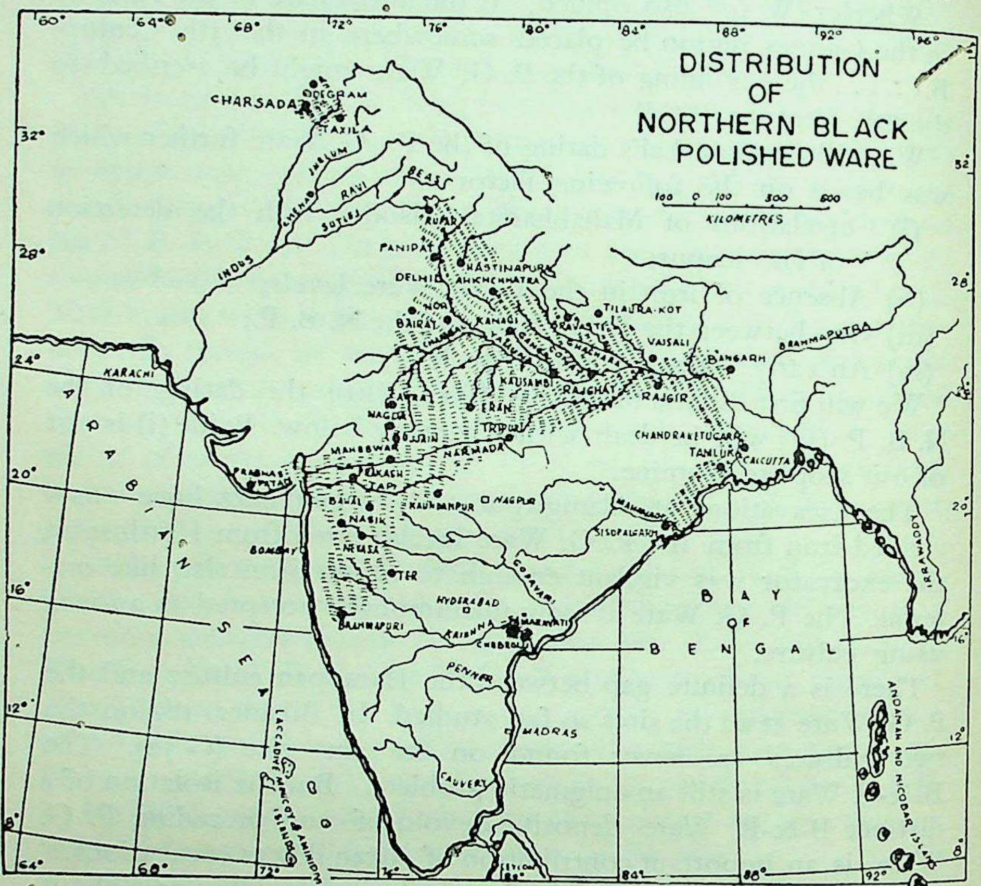
DISTRIBUTION OF NORTHERN BLACK POLISHED WARE
100 0 100 300 500
KILOMETRES
60°
64°
68°
72°
76°
80°
84°
88°
92°
96°
32°
28°
24°
20°
16°
12°
8°
CHARSADA
UDEGRAM
TAXILA
JHELUM
CHENAB
RAVI
BEAS
SUTLEJ
INDUS
RUPAR
PANIPAT
HASTINAPURA
DELHI
AHICHCHHATRA
NOH
BAIRAT
KANAGI
CHAMBAL
YAMUNA
GANGA
GOMATI
GHAGHARA
SRAVASTI
TILAURA-KOT
VAISALI
BANGARH
BRAHMAPUTRA
KAUSAMBI
RAJGHAT
RAJGIR
AVRA
ERAN
NAGDA
UJJAIN
TRIPURI
MAHESWAR
NARMADA
PRAKASH
TAPI
PRABHAS PATAN
KARACHI
BAHAL
KAUNDANPUR
NAGPUR
NASIK
NEVASA
BOMBAY
TER
HYDERABAD
BRAHMAPURI
KRISHNA
AMARAVATI
CHEBROLU
GODAVARI
MAHANADI
SISUPALGARH
CHANDRAKETUGARH
TAMLUK
CALCUTTA
PENNER
MADRAS
CAUVERY
CEYLON
IRRAWADDY
ARABIAN SEA
BAY OF BENGAL
LACCADIVE MINICOY & AMINIDIVI ISLANDS
ANDAMAN AND NICOBAR ISLANDS

Fig. 3. Map showing the distribution of the N.B.P.Ware.

connection the ferruginous slip that imparts the N. B. P. its distinctive gloss becomes very meaningful indeed.

From the foregoing discussions the following possibilities emerge:

(i) A redware industry forming some sort of a substratum in the Doab on which impinge the P. G. Ware from the west and the N. B. P. from the east.

(ii) The redware shapes common to the P. G. Ware in the west and the N. B. P. in the east suggest some contemporaneity, between the two, with the probability that the P. G. Ware had an earlier beginning.

(iii) A clear temporal succession of the P. G. Ware and the N. B. P. in the spatial zones of overlap may represent a stage when the ecological barrier of the thick Doab forests was more or less cleared (Chapter 7).

(iv) The degenerate P. G. Ware of Rajghat, Vaishali and Kausambi is much later than at its home in the west.

(v) The western and southern N. B. P. is later than its eastern counterpart, as indicated by the association of the post-N. B. P. red ware types of the east.

(vi) A straight line linking Tilaurakot, Sravasti and Kannauj should effectively divide the original zones of the P. G. and N. B. P. wares.

More interesting and rewarding would be a study of total assemblages and the red wares associated with the P. G. and N. B. P. Wares. If we take into consideration the frequency of the P. G. Ware (e.g. 3-10% at Atranjikhera) and the N. B. P. in the total ceramic assemblage we find that both of these are essentially deluxe wares. So a detailed study of frequency distribution will clearly bring out: (i) epicentres and concentration zones of the P. G. and N. B. P. wares and; (ii) their deluxe nature.

With this background we will now study the associated red ware shapes. We find that the peach shaped vases (Ahichchhatra 10A type), carinated *handi* and miniature bowls are found with the N. B. P. at Hastinapur, Ahichchhatra, even at Prakash. But these very shapes are post-N. B. P. in Sravasti (Si 6F) and Rajghat. On the other hand, many Hastinapur Pd II red ware shapes occur at Sravasti along with the N. B. P. ware as also at Rajgir and Vaishali.

Sinha goes further. The corrugated bowl "would lend further weight to the assumption that the P. G. Ware, the Black Polished Ware and the N. B. P. represent basically a common tradition—particularly in the form of fabric conception and that on this consideration, any substantial time gap between the wares is not justified" (Si the). To confirm this interesting postulate, we need more published evidence.

We have seen that the clear temporal succession of the P. G. and N. B. P. wares as seen in western sites may only be partially true. If we take spatial distributions also into account a period of contemporaneity, though not essentially contact, may also be discerned for these two wares.

It may be emphasised that four facts militate against the probability of a common stock of the P. G. Ware and the N. B. P.: (i) their primary distribution zones are different; (ii) the unique painting tradition of the P. G. Ware; (iii) the finely controlled firing of the P. G. Ware to produce the characteristic grey colour and; (iv) the special slip which provides the distinctive gloss of the N.B.P. The similarity of fabric is only due to the same alluvial clay of the Doab available for both the ceramics.

We saw that the P. G. Ware can no more be called 'Chalcolithic' and with that appellation goes the aura of its antiquity. It is evidently an iron using culture, partly contemporaneous to the N.B.P. and coming well upto the threshold of urbanisation in Doab. On the whole, a beginning before 1100 B. C. for the P. G. Ware is thus untenable. In the archaeological evidence there is nothing to suggest an antiquity greater than *ca.* 9th-8th century B. C. for this ware. In this light, Wheeler's (W 59) estimate of *ca.* 800-500 B. C. seems to be quite plausible.

A. (v) *Archaeological Dating of N. B. P. Ware*

The N. B. P. has a very wide distribution, obviously ascribable to different parts of its time bracket. From "Charsada near Peshawar and Udegram in Swat in the north, Tilaurakot in the Nepalese 'Tarai', Prabhas Patan on the Kathiawar littoral in the West, Ujjain, Maheshwar and Nasik on the trunk route from the Ganga Yamuna Doab to the Arabian sea, Ter and Brahmapuri in the Deccan, Kauandanpur, Eran and Tripuri in the Central part of India, Chandraketugarh and Berachampa in the east", (Th 67) upto Chebrolu, further south of the famous Buddhist site of Amravati in the south is spread its geographical distribution (Fig. 3).

As far as the dating goes, we will first quote Lal's (Lal 54-55) arguments. As noted above there was a conflagration at the end of Pd III (N. B. P.). Pd IV beginning was dated, on the basis of Mathura coins, to *ca.* 200 B. C. The gap between Pds III and IV was surmised to be of a century in duration. At Hastinapur-1, 5′-9′ of habitational débris and at Hastinapur-2, 9′ was discovered.

Despite a small number of walls, as admitted by Lal, he distinguished six sub-periods in this deposit and ascribing 50 years to each sub-period, gave 300 years to Pd. III, thus placing the beginning of the N. B. P. at the site to *ca.* 600 B. C.

To substantiate his dating he quoted the Kausambi evidence. "Here (Trench KS III) the first three layers above the natural soil, viz. layers 27 to 24, yielded sherds of grey ware, though only four in number. They included fragments of bowls, one of which was also painted with a simple band round the rim in black pigment. Above these layers was a sterile deposit of clay, about 6′-7 in thickness. The first layer overlying this clay, viz., layer 16, yielded the N. B. P. which continued till layer 8. The total thickness of the N. B. P. bearing strata was about 8′, wherein were noticed six occupational phases during which mud or mud-bricks were used and two further phases having structures of kiln-burnt bricks. From layer 7 upwards were obtained coins of the Mitra rulers of Kausambi, assignable to the second century B. C. This shows that the N. B. P. had come to an end by the beginning of that century. With this as the upper limit, and with eight occupational phases to go by, the beginning of the N. B. P. at Kausambi may safely be assigned to early sixth century B. C." (Lal 54-55).

Lal used Taxila evidence also in favour of an early dating of the N. B. P. Out of the two Sirkap sherds one came from the earliest levels (*ca.* 200 B. C.); the other was unstratified. Out of thirteen sherds from Bhir mound, 12 were recovered from 6′-13 depth. A coin of Alexander in mint condition was recovered at an average depth of 6′ below surface. On this basis the 6′ deposit was ascribed to *ca.* 300 B. C. and the underlying débris of 7′ was given another 300 years, thus placing the advent of the N. B. P. in *ca.* 600 B.C.

We thus see that there is no way of dating the occupational débris on the basis of depth alone. Lal himself assigned the same 300 years to 7′ of Bhirmound, 8′ of Kausambi and 9′ of Hastinapur !

On the basis of the same evidence Wheeler (W 59) says, "Since Taxila was not dug stratigraphically in the modern usage of the term, these depths are an unreliable guide. But, on the showing, the N. B. P. may be ascribed to 5th–2nd centuries B.C." On the basis of Charsada (W 62) and Udegram evidence, he "would provisionally ascribe the N.B.P. of the north western regions of the subcontinent to the period 320-150 B. C., without prejudice to the possibility of an appreciably earlier beginning in the Ganges basin itself" (W 59). According to Sinha (Si the), however, there is a good case for retaining the earlier date bracket for Taxila, Both Thapar (Th 67) and Wheeler (W 59) ascribe its wide distribution to the Mauryan expansion. But Sinha (Si the) disagreed on the ground that the formative period of the use of the N. B. P. in mid-Ganges plains antedated the spread of the Mauryans and after 300 B. C. its occurrence in the region is insignificant. If it was a ware of the Mauryan expansion, its near absence at Kumrahar, identified with Pataliputra, is unaccountable. On the contrary, Rajgir—a pre-Mauryan capital—is richer in it. He thinks that its primary centres are Kausambi, Rajgir, Vaishali and Sravasti. And the secondary distribution centres, according to him, are Hastinapur, Rupar, Ujjain, Kumrahar, etc. Taxila, because of trade links, is included in primary distribution sites. He, too, therefore emphasises that the N. B. P., alone cannot be taken as a safe dating criterion. The associated assemblage should be given more importance. He also admits long survival of the N. B. P. It was popular and abundant only in the primary sites.

The P. G. Ware has clearly a western distribution. Though the fabric is similar to the N. B. P., it is a distinctive ware, with very well controlled firing of pottery and a characteristic painting tradition. The black-slipped and N. B. P. wares could be analogous, but not the P. G. Ware. Similarity in fabric (as noted above) is more due to the availability of fine clay in the Doab for making such a fine pottery. The N. B. P., it should be noted, is an unpainted pottery tradition.

Coming back to the problem of chronology of the N. B. P., the upper limit, on the basis of the evidence discussed above, could be in the first century B. C. The beginning is still not defined, but could be in Buddha's times. Because of the lack of uniformity regarding the basis of labelling of the N. B. P. deposits, the evidence is not amenable to finer distinctions. (Some excavators describe levels yielding even a few sherds of the N. B. P. as the N. B. P. levels.) Thus archaeological evidence can only loosely confine the N. B. P. within *ca.* 550-100 B. C.

II. B. C.^{14} DATING IN INDIA

Below, will be discussed the chronologies of various protohistoric cultures based on C^{14} dating. Though primarily the conclusions depend upon the large number of C^{14} determinations carried out by me at the Tata Institute (in collaboration with Kum. Sheela Kusumgar and Shri R. P. Sarna); I have also collected all the relevant C^{14} dates determined by various foreign laboratories. All discussions are based on C^{14} dates in years B. C.* and on the half-life value of 5730 years. Figure 4 gives an overall picture of the chronologies of the various cultures based on C^{14} dating.

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* Unless mentioned otherwise

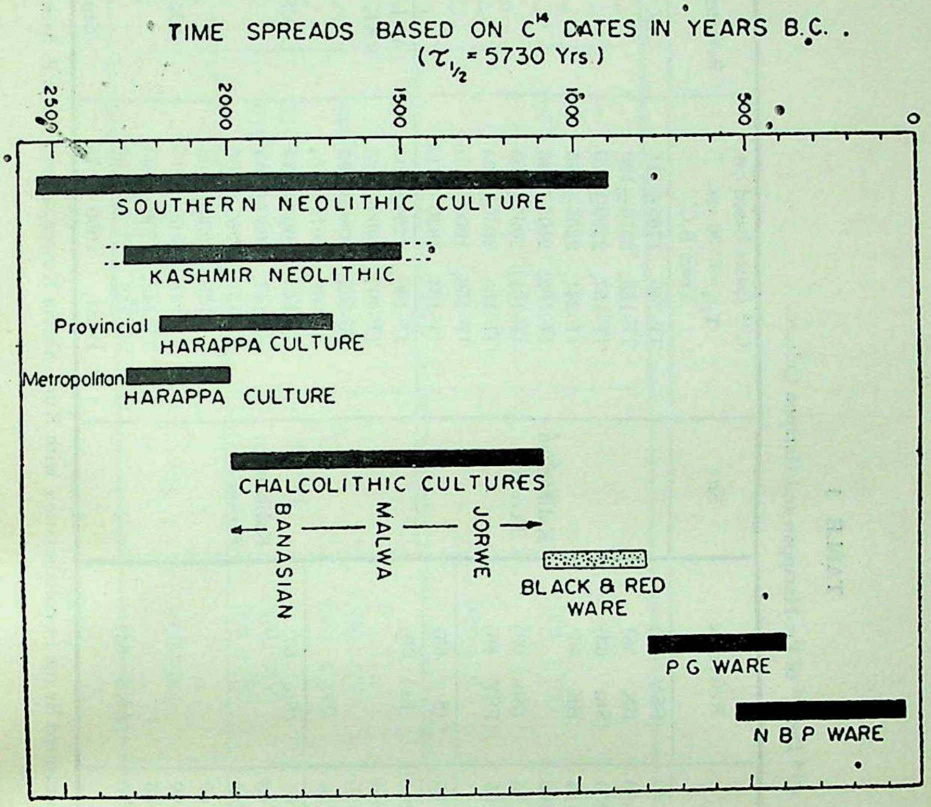

Fig. 4. The timespreads of the cultures existing between 0-2500 B.C. (based on C^{14} dates)

B. (i) *Pre-Harappan Chronology*

For these cultures (Fig. 5, Table 1) the seven dates from Damb Sadaat, one from Niai Buthi and four from Kot Diji are all we have to go by. In India, from Kalibangan Pd I we have nine C^{14} dates.

Three Damb Sadaat II dates (L-180 C, 2220±410; L-180E, 2220±360; P-523, 2200±75), out of total four, cluster around 2200 B.C. There is only one Damb Sadaat III date, UW-60, 2140±165. For Damb Sadaat I, there are two dates: L-180 B, 2320±360 and UW-59, 2510±70, within one standard deviation both are the same. Adding one standard deviation error to 2510 we get 2580 B. C. for Damb Sadaat I. We can at the latest place Damb Sadaat III at *ca.* 1975 B. C. by subtracting one standard deviation

TABLE 1

C^{14} Dates* of Pre-Harappan and Harappa Cultures

Site	C^{14} Dates based on $\tau_{1/2}$=5730 yrs. Years B.C.		Reference	Site	C^{14} Dates based on $\tau_{1/2}$=5730 yrs. Years B.C.		Reference
Damb-Sadaat	UW-59,	2510± 70	(FSY 66)	Kalibangan Period-I	TF-240,	1765±115	(AK 68)
	L-180B,	2320±360	(BK 56)		TF-155,	2370±120	,,
	P-522,	2550±200	(Stu 63)		TF-157,	2290±120	,,
	L-180C,	2220±410	(BK 56)		TF-241,	2255± 95	,,
	L-180E,	2220±360	,,		TF-162,	2105±105	,,
	p-523,	2200± 75	(Stu 63)		TF-161,	2095±105	,,
	UW-60,	2140±165	(FSY 66)		TF-165,	1965±105	,,
Niai Buthi	P-478	1900± 65	(Stu 63)		TF-156,	1900 ±110	,,
Kot Diji	P-196,	2600±145	(Ral 59)		TF-154,	1820 ±115	,,
	P-179,	2330±155	,,	Kalibangan Period-II	TF-160,	2230±105	(AKL 65a)
	P-180,	2250±140	,,		TF-607,	2090±125	(AK 68)
	P-195,	2100±140	,,		TF-163,	2080±105	,,
Mohenjodaro	P-1177,	2155± 65	(Stu 67)		TF-608,	2075±110	,,
	P-1179,	2085± 65	,,		TF-145,	2060±105	(AKS 64a)
	P-1180,	1995± 65	,,		TF-147,	2030±105	,,
	P-1176,	1965± 60	,,		TF-151,	1960 ±105	,,
	P-1178A,	1965± 60	,,		TF-139,	1930 ±105	,,
	P-1182A,	1865± 65	,,		TF-141,	1860 ±115	(AK 68)
	TF- 75,	1755±115	(AKS 64)		TF-142,	1790 ±105	,,
					TF-152,	1770 ± 90	,,
					P-481,	2050 ± 75	(Stu 63)

* C^{14} dates with TF numbers have been measured by me in collaboration with Kum. Sheela Kusumgar and Sri *R.P. Sarna.*

TABLE 1—(contd.)

Site	C^{14} Dates based on $\tau_{1/2}$=5730 yrs. Years B.C.	Reference	Site	C^{14} Dates based on $\tau_{1/2}$=5730 yrs. Years B.C.	Reference
Kalibangan Period-II	TF- 25, 2090 ±115	(KLS 63)	Lothal	TF-29, 1895 ±115	(KLS 63)
	TF-153, 2075 ±110	(AK 68)		TF-23, 1865 ±110	,,
	TF-605, 1975 ±110	,,			
	TF-150, 1900 ±105	(AKS 64a)		TF-19 1800 ±140	,,
	TF-149, 1830 ±145	(AK 68)			
	TF-143, 1665 ±110	,,			
	TF-244, 1390 ± 95	,,			
Lothal	TF-138, 1215 ±105	,,	Rojdi		
	TF-136, 2080 ±135	(AKS 64a)			
	TF-135, 1555 ±130	,,			
	TF-133, 1895 ±115	,,		TF-200, 1970 ±115	(AKS 64a)
	TF- 22, 2010 ±115	(KLS 63)		TF-199, 1745 ±105	,,
	TF- 27, 2000 ±115	,,			
	TF- 26, 2000 ±125	,,			

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from 2140 (UW-60). Thus, we see that Damb Sadaat II and III are partly contemporaneous to the Harappa culture. Damb Sadaat I sample is from level 160, Test Pit AT, representing Kechi Beg phase in Quetta Valley which has typological ties with Pre-Harappa of Kot Diji and Amri* in Sind (FSY 66). Thus on the basis of the available C14 dates these Pre-Harappan cultures (Phase E) date to *ca.* 2600 B.C.

From Kot Diji four C14 dates are available, all from the Pre-Harappan period. P-196, 2600 ± 145 is from Layer 14, citadel area and belongs to an early phase (Pak 65). P-195, 2100 ± 140 is also from citadel area but from a late phase, Layer 4. From outer city area are P-180, 2250±140 and P-179, 2330 ±155. Even if we add one standard deviation error to 2100, it goes to only 2240 B. C. In view of other dates (P-195, P-180 and P-179), for the early phase we have taken *ca.* 2600 B. C., on the basis of P-196, though with the error it can go back to *ca.* 2700 B. C. Because of very few determinations, and large errors, greater precision is not warranted.

There is only one date for Niai Buthi P-478, 1900±65. The site has Kulli affiliations. It would date the site to *ca.* 2000 B. C. From Kalibangan Pd I nine samples have been dated (Table 1). Only TF-240, which derived from immediately below a faulted stratum, shows younger age. All the rest show a reasonable internal consistency in consonance with stratigraphy. For the late phase there are three dates : TF-154, 1820±115, TF-156, 1900 ±110 and TF-165, 1965±105. Within one standard deviation they are about the same. But as discussed elsewhere (AK 68), it has to be borne in mind that most of the Pd I samples come from the peripheral portions of the mound, where contamination with modern humic acid (which has double the natural amount of C14 activity due to the bomb produced radiocarbon) coupled with errors of ±100 years could show a much younger date. It would be safe to add one standard deviation error to the central date of 1900±110. This will place the end phase of Pd I at Kalibangan to *ca.* 2000 B. C. In any case the beginning of Harappan occupation on mound-1 appears to be later than that of mound-2. From the early phase of Pd I we have dated four samples. TF-155, 2370±120 is the earliest as it comes from just above the natural soil. The other two are : TF-157, 2290±120; TF-241, 2255±95 B. C. As all the three samples come from the early levels we have compounded the errors. The mean date for the

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*It is interesting to note the recent dates for Amri IB, TF—864, 2900±115 B. C. and for Amri IC, TF—863, 2665±110 B. C.

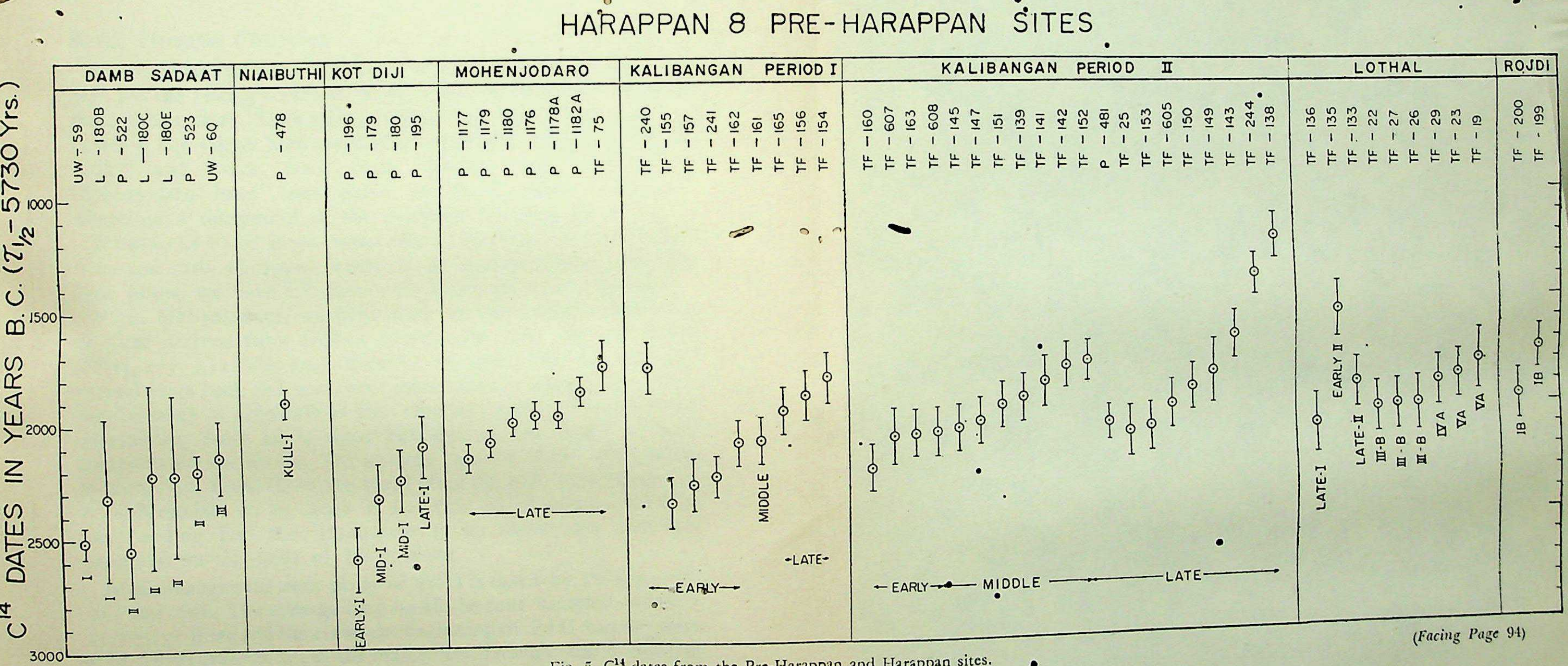

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Fig. 5. C^{14} dates from the Pre-Harappan and Harappan sites.

early phase is 2295±65. Adding one standard deviation error on it, it comes to 2360 B. C. viz. *ca.* 2400 B. C. (TF 162 has not been considered reliable as it derives from immediately below the faulted strata). Thus on the basis of C^{14} dates we can assign a bracket of *ca.* 2400-2000 B. C. to the Pre-Harappans at Kalibangan.

B. (ii) *Harappan Chronology*

In 1964, I had proposed (Ag 64) a time spread of *ca.* 2300-1750 B.C. for the Harappa culture on the basis of the (then) available radiocarbon dates. Since then, a large number of measurements (Table 1, Fig. 5)have been made by us on samples from Kalibangan, Lothal and Rojdi. Some more samples from late levels of Mohenjodaro have been dated by Pennsylvania University. Therefore, a reappraisal of the evidence is called for.

It has to be stated at the outset that so far there are no C^{14} dates from real early Harappan levels of the metropolitan centres. For early phase, we have C^{14} dates only from the 'provincial' sites.

From Mohenjodaro, we have now seven determinations, six of these derived from Dales's excavations. The one we dated, TF-75, 1755±115 also came from the late levels but was collected several years back and was never meant for C^{14} dating. So it cannot be taken as authentic as the samples collected from Dales' excavations. Since all of these belonged to late levels we have compounded the errors. The average date on these six samples is 2005±25. From these one could place the end of the Harappans at Mohenjodaro to *ca.* 2000 B. C. This is obviously quite an early ending for the Harappans at its metropolis than was proposed on the basis of TF-75 alone.

At Kalibangan the early phase of Pd II is dated by TF-160, -607, -163 and -608. The average date on all the four samples comes to 2125±55. If we add the error, the beginning of Pd II can be placed at *ca.* 2200 (2180) B. C., at the maximum. Though the middle and early phase samples are quite consistent, the late phase shows scatter. TF-138, TF-244 and TF-143 are obviously contaminated, as derived from near the surface. It appears *ca.* 1700-1800 B. C. would be a safe limit for the end, though the evidence needs further confirmation. From Lothal VA, TF-23, 1865±110 and TF-19, 1800±140 also suggest an end around that time. Giving the maximum spread, by subtracting one standard deviation error from TF-149, 1830±145, we get *ca.* 1700 for the end. TF-149 derives from a depth of 0.65 m. and was treated with sodium hydroxide too for the removal of humic acids.

Thus the available dates suggest that for the peripheral Harappan regions the maximum spread could be *ca.* 2200-1700 B. C.

But for the metropolitan regions we do not have any C^{14} dates from early phases. We can only extrapolate on the basis of Damb Sadaat II and Kot Diji I dates. For Damb Sadaat II all the three dates L-180C, L-180E, P-522, are consistent, keeping in view their large errors. However, P-523, 2200±75 has a smaller error. Taking one standard deviation on this date we can safely put it to *ca.* 2300 (2275) B. C. Thus Damb Sadaat II provides the anterior limit to the beginning of Harappa culture. At Kot Diji the latest Pd I levels are dated by P-195, 2100±140. Taking one standard deviation on it we can place the end of Kot Diji I to *ca.* 2240 B. C. On this basis, if we extrapolate, we can place the beginning of Harappans at Mohenjodaro to *ca.* 2300 B. C. Thus the bracket for the metropolis would be *ca.* 2300-2000 B.C., whereas for the provincial regions it is *ca.* 2200 to 1800-1700 B. C.

From the foregoing it is evident that the Harappa culture was never an Empire but a shifting phenomenon both spatially and temporally. Whereas it came to an end around *ca.* 2000 B. C. in the metropolis, it lingered on in the provincial regions (Fig. 1) till *ca.* 1700 B. C.

It is interesting to note here that the southern neolithic culture had a long spread (Table 2) from *ca.* 2550-900 B. C. And it coexisted with the Harappans as also with the other Chalcolithic cultures. When plotted latitudinally (Fig. 6) the northern sites gave older dates than the southern sites. Does this indicate any migratory pattern ?

B. (iii) *Chronology of the other Chalcolithic Cultures*

So far we had TF-34, 1725±140 for Ahar Ia, as the only earliest date. Now we have five more dates (Table 3, Fig. 7) from Ahar Ia. Since all belong to the same phase we have taken the mean, using relation (4), which comes to 1995±45. Thus we can place the beginning of Ahar Ia *ca.* 2000 B. C.

Next comes the Malwa Ware site of Navdatoli. P-476 is obviously too early for Phase II, and is divergent. TF-59, P-475, P-200 and P-201 are from Phase I. Taking one standard deviation on TF-475, 1610±70, we obtain *ca.* 1700 (1680) B. C. as the beginning of Navdatoli Phase I. Sonegaon, Nevasa and Chandoli, all Jorwe ware sites, have several C^{14} dates. On the graph (Fig. 7) we can clearly see a maximum time spread of *ca.* 1500-900 B. C. Though most of the C^{14} dates cluster around 1400-1300 B. C.

TABLE 2

C^{14} Dates* of Southern Neolithic Sites

Site	C^{14} dates based on $\tau_{1/2} = 5730$yrs. Years B.C.		Reference
Kodekal	TF-748	2460±105	(AK pre)
Utnur	BM-54, TF-167, TF-168,	2295±155 2050±115 2040±115	(BMa 60) (AKS 64a) ,,
Terdal	TF-684, TF-683,	1935±100 1770±120	(AK 67) ,,
Tekkalakota	TF-266, TF-237, TF-262, TF-239,	1780±105 1615±105 1610±140 1540±105	(AKL 65) ,, ,, ,,
Sangankallu	TF-354, TF-355, TF-359,	1590±110 1585±105 1550±105	(AK 66) ,, ,,
Palvoy	TF-701,	1965±105	(AK pre)
Hallur	TF-580, TF-576, TF-586, TF-570, TF-575, TF-573,	1710±105 1425±110 1195±100 1105±105 1030±105 955±100	(AK 66) (AK pre) ,, (AK 66) ,, ,,
Bainapalli	TF-349,	1485±100	(AK 66)
T. Narsipur	TF-412, TF-413,	1805±110 1495±110	(AK 66) ,,

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*C^{14} dates with TF numbers have been measured by me in collaboration with Kum. Sheela Kusumgar.

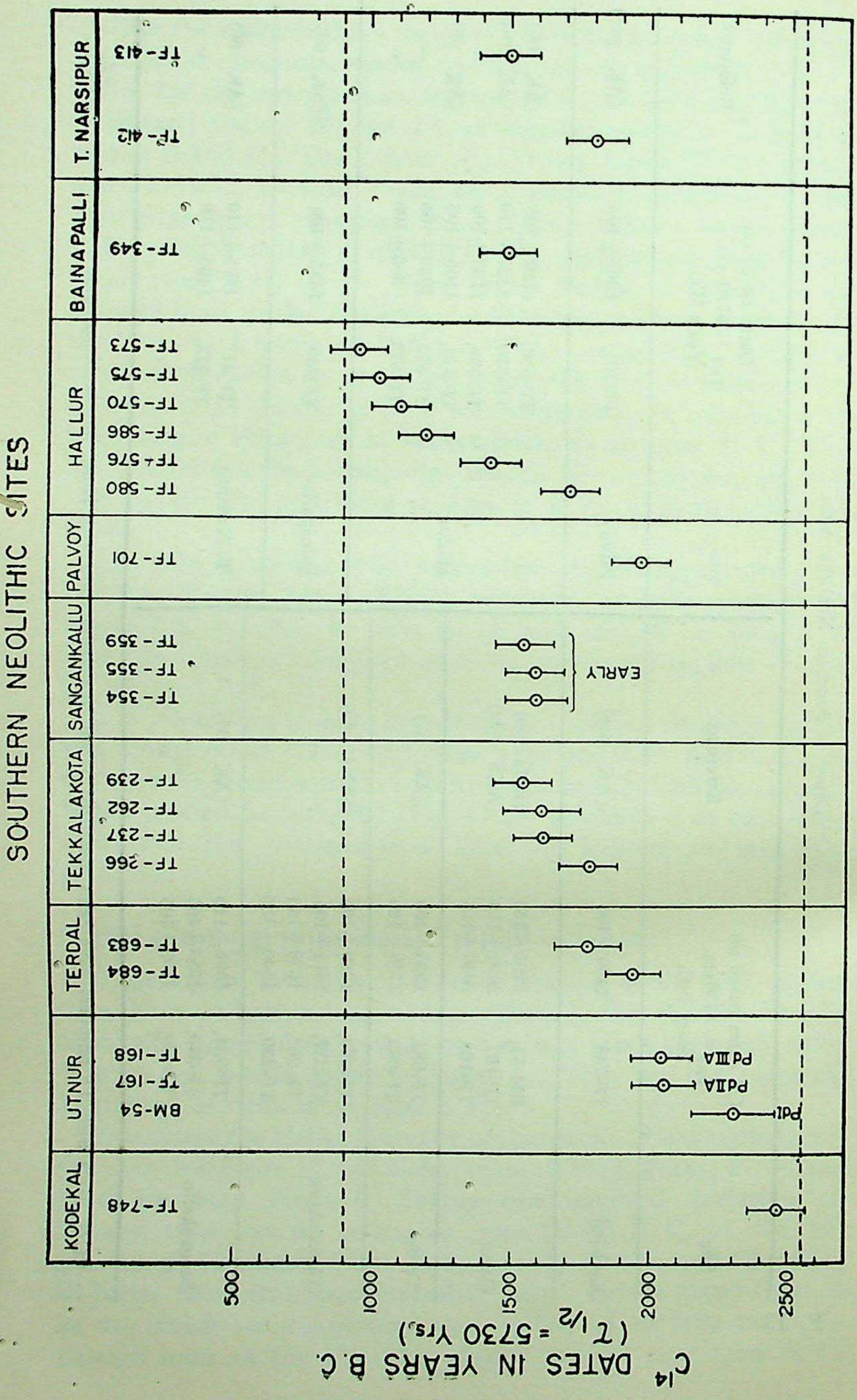

Fig. 6. C^{14} dates from the southern neolithic sites.

TABLE 3

C^{14} Dates* of Chalcolithic Sites

Site	C^{14} Dates based on $\tau_{1/2}$=5730 yrs. Years B.C.	Reference
Ahar	V-57, 2145±100	(Be 66)
	V-58, 2055±105	,,
	V-54, 2000±100	,,
	V-55, 1990±125	,,
	V-56, 1875±100	,,
	TF-34, 1725±140	(KLS 63)
	TF-37, 1305±115	,,
	TF-32, 1550±110	,,
	TF-31, 1270±110	,,
Navdatoli	P-201, 1645±130	(Ral 59)
	P-200, 1610±130	,,
	P-475, 1610± 70	(Stu 63)
	TF-59 1525±110	(KLS 63)
	P-476, 2300± 70	(Stu 63)
	P-202, 1660±130	(Ral 59)
	P-204, 1600±130	,,
	P-205, 1445±130	,,
Eran	TF-331, 1500± 95	(AK 68a)
	TF-330, 1365±100	,,
	P-528, 1015± 65	(Stu 63)
	TF-329, 1445±110	(AK 68a)
	P-527, 640 ± 60	(Stu 63)
	P-526, 1280± 70	,,
	TF-327, 1425±105	(AK 68a)
	P-525 1340± 70	(Stu 63)
	P-529, 2035± 75	,,
Sonegaon	TF-384 1565±110	(AK 68a)
	TF-382, 1340±100	,,
	TF-380, 1375±110	,,
	TF-379, 1290± 95	,,
	TF-383, 1330±100	,,
Chandoli	P-473, 1330± 70	(Stu 63)
	P-472, 1300± 70	,,
	TF-43, 1040±105	(KLS 63)
	P-474, 1240±190	(Stu 63)
	TF-42 1170±120	(KLS 63)
Nevasa	TF-40, 1250±110	(KLS 63)
	P-181, 1250±125	(Ral 59)
Mahisdal	TF-391, 1380±105	(AK 68a)
	TF-392, 1085±110	,,
	TF-390, 855 ±100	,,
Chirand	TF-334, 845 ±125	(AKU 66)
	TF-444, 715 ±105	(AK Pre)
	TF-445, 1650±100	,,

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*C^{14} dates with TF numbers have been dated by me in collaboration with Kum. Sheela Kusumgar.

TABLE 4

C^{14} Dates* of P.G. Ware Sites

Site	C^{14} Dates based on $T_{1/2}$ =5730 yrs. Years B.C.		Reference
Noh	UCLA-703B,	820±225	(BF 65)
	UCLA-703A,	605±260	,,
Hastinapur	TF- 91,	570±125	(AKS 64a)
	TF- 85,	505±130	(AKS 64)
	TF- 90,	390±115	,,
	TF-112,	375±100	(AKS 64a)
	TF- 83,	335±115	(AKS 64)
Atranjikhera	TF-191,	1025±110	(AKS 64a)
	TF-291,	535±100	(AKU 66)
Tilaurakot	TF-737,	350±95	(AK pre)

*C^{14} dates with TF numbers have been determined by me in collaboration with Kum. Sheela Kusumgar and Sri R.P. Sarna.

(cf. TF-380, TF-382, TF-383, TF-379, P-473, P-472, PF-474, TF-40, P-181).

We cannot sharply differentiate between the different cultures, but approximate spreads can be discerned. The Banasian starts *ca.* 2000 B. C. and goes upto 1600 B. C.; the Malwa culture begins *ca.* 1700 B. C. and continues upto *ca.* 1400 B. C.; the Jorwe culture may have extended from *ca.* 1500 to *ca.* 900 B. C., at the *maximum*. But it should be emphasised that except for TF-43, 1040±105 (Chandoli), no other date is younger than *ca.* 1200 B. C. Both this as well as the cluster of C^{14} dates around 1400-1300 B. C. would indicate a compacter chronology of *ca.* 1400-1100 B. C. for the Jorwe culture. Chirand and Mahishdal are roughly contemporaneous to the Jorwe culture, and lasted longer.

B. (iv) *P. G. Ware Chronology*

Of the early samples (Table 4, Fig. 8) we have UCLA-703B and UCLA-703A. The published details (BF 65) of the last two are not clear, but the samples are said to derive from a depth of over 6′. It must be admitted that we do not have well stratified samples to determine the date of the early phase. Though we could extend the earlier limit maximum to *ca.* 1000 B. C. on the basis of TF-

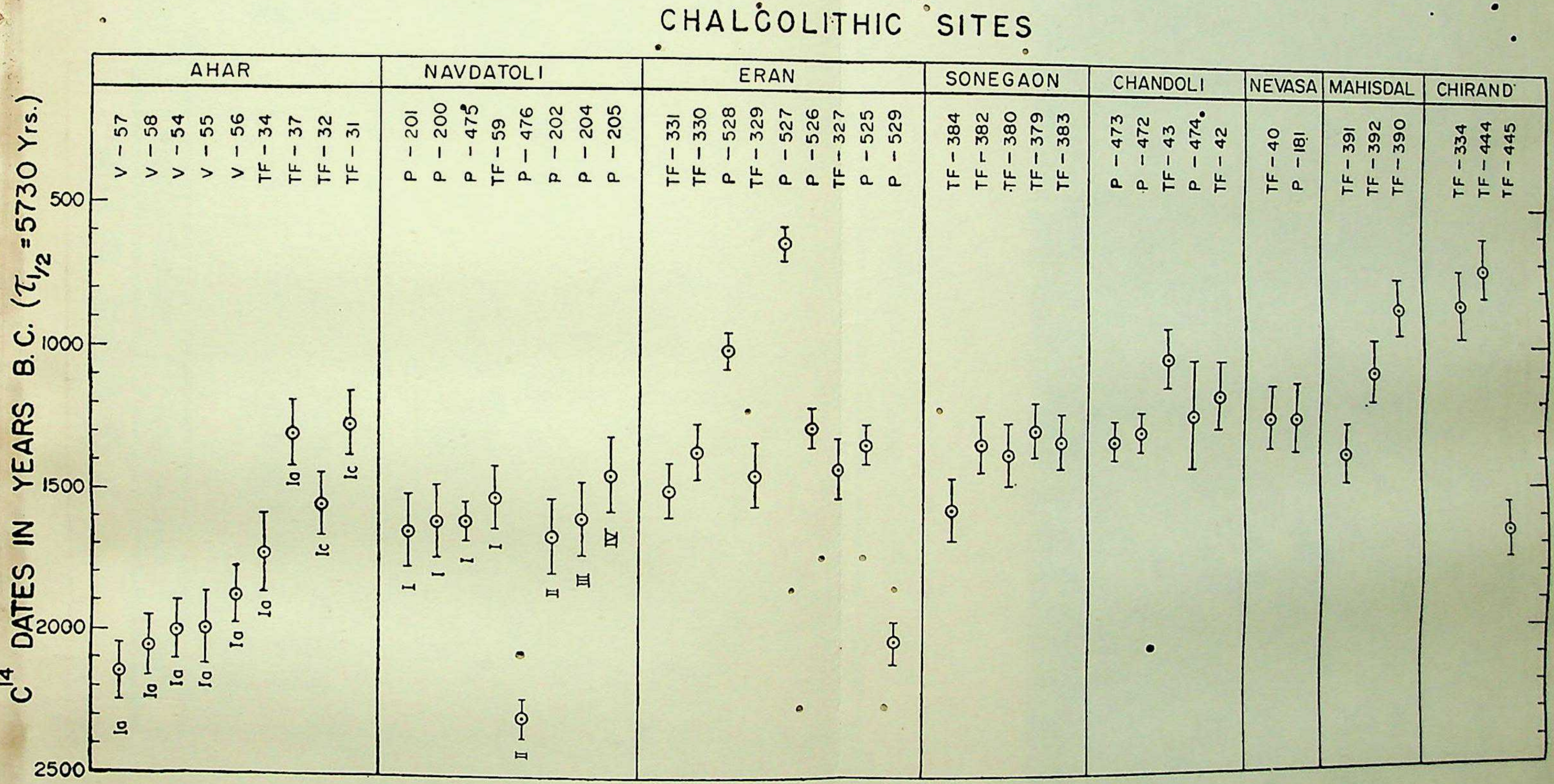

Fig. 7. C¹⁴ dates from the Chalcolithic sites of the Banasian, the Malwa and the Jorwe cultures.

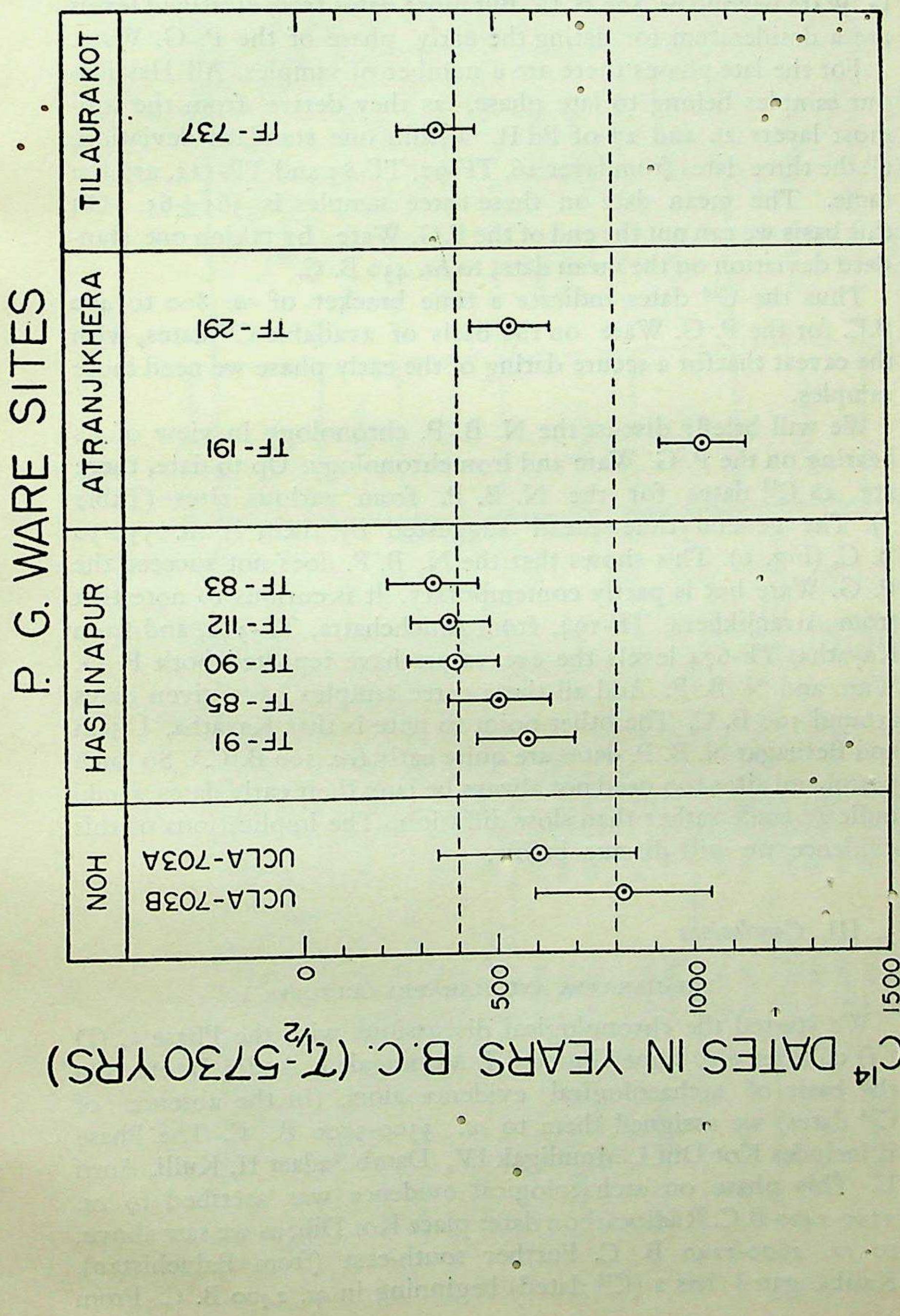

Fig. 8. C^{14} dates from the P.G. Ware sites.

191, yet we cannot place much reliance on it in view of later C^{14} dates of B-&-R Ware levels from the same site. At the moment there is nothing that can warrant placing the beginning of the P. G. Ware beyond *ca.* 800 B. C. But more dates from stratified levels are a desideratum for dating the early phase of the P. G. Ware.

For the late phases there are a number of samples. All Hastinapur samples belong to late phase, as they derive from the topmost layers 26 and 27 of Pd II. Within one standard deviation, all the three dates from layer 26, TF-90, TF-83 and TF-112, are the same. The mean date on these three samples is 365±65. On this basis we can put the end of the P.G. Ware, by taking one standard deviation on the mean date, to *ca.* 430 B. C.

Thus the C^{14} dates indicate a time bracket of *ca.* 800 to 400 B.C. for the P. G. Ware on the basis of available C^{14} dates, with the caveat thatfor a secure dating of the early phase we need more samples.

We will briefly discuss the N. B. P. chronology in view of its bearing on the P. G. Ware and iron chronology. Up to date, there are 28 C^{14} dates for the N. B. P. from various sites (Table 5). The general time-spread suggested by them is *ca.* 550-50 B. C. (Fig. 9). This shows that the N. B. P. does not succeed the P. G. Ware but is partly contemporary. It is curious to note that from Atranjikhera, TF-194, from Ahichchatra, TF-311, and from Kayatha, TF-674 levels the excavators have reported both P. G. Ware and N. B. P. And all these three samples have given dates around 500 B. C. The other point to note is that Kayatha, Ujjain and Besnagar N. B. P. dates are quite early (*ca.* 500 B. C.). So such peripheral sites too need not always be late; their early dates would indicate trade rather than slow diffusion. The implications of this evidence we will discuss below.

3. III. *Conclusions*

PRE-HARAPPA AND HARAPPA CULTURES

We started the chronological discussions with the Phase C (D 65) cultures e.g. Rana Ghundai I, Mundigak I, Anjira II, etc. On the basis of archaeological evidence alone (in the absence of C^{14} dates) we assigned them to *ca.* 3300-3000 B. C. The Phase E includes Kot Diji I, Mundigak IV, Damb Sadaat II, Kulli, Amri II. This phase on archaeological evidence was ascribed to *ca.* 2700-2400 B.C. Radiocarbon dates place Kot Diji, as we saw above, to *ca.* 2600-2240 B. C. Further south-east (from Baluchistan), Kalibangan I has a (C^{14} dated) beginning in *ca.* 2400 B. C. From

TABLE 5

C^{14} Dates* of N.B.P. Ware Sites

Site	C^{14} Dates based on $\tau_{1/2}$=5730 yrs. Years B.C.	Reference
Rupar	TF-209, 485 ±100 TF-213, 390 ±105	(AKL 65) (AKU 66)
Hastinapur	TF- 88, 340 ±115 TF- 81 125 ±100 TF-80 & 82 50 ±115	(AKS 64) (AKS 64a) (AKS 64)
Atranjikhera	TF-194, 530 ± 85 TF-284, 295 ±100 TF-283, 260 ±105	(AKU 66) ,, ,,
Ahichchhatra	TF-311, 475 ±105 TF-310, 160 ± 95	(AKU 66) ,,
Hetimpur	TF-176, 105 ±105 TF-177, 80 ±105 A.D.	(AK 65) ,,
Kausambi	TF-221, 500 ±105 TF-219, 440 ±100 TF-103, 410 ±110 TF-225, 400 ±110 TF-105, 335 ±115 TF-100, 275 ±100 TF-104, 270 ±110 TF-226, 220 ±100	(AKL 65) ,, (AK 65) (AKL 65) (AK 65) (AKS 64a) (AK 65) (AKL 65)
Rajghat	TF-293, 490 ±110	(AKU 66)
Chirand	TF-446, 35 ±105	(AK Pre)
Rajgir	TF-45, 265 ±105 TF-46, 260 ±100	(KLS 63) ,,
Ujjain	TF-409, 450 ± 95	(AK pre)
Kayatha	TF-674 470 ±100	(AK pre)
Besnagar	TF-387, 470 ±105 TF-254, 295 ±110	(AKU 66a) (AKL 65)

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* The C^{14} dates have been measured by me in collaboration with Kum. Sheela Kusumgar and Sri R.P. Sarna.

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both archaeological and radiocarbon dating evidence, it is evident that around 2400 B. C. Pre-Harappa cultures were in existence. Whether they were partly contemporary to Mohenjodaro early levels canno tbe said at this stage. But it is certain that after *ca.* 2700 B. C. a transition from village to fortified settlements was taking place as evidenced at Kot Diji and Mundigak. The metallurgical techniques make their first appearance in this region in Mundigak I and are gradually transmitted to the eastern sites.

In the case of the Harappan chronology, we have more data to arrive at definite conclusions. We analysed archaeological evidence in detail and found that it does not permit us to push the beginning of the Harappa culture beyond *ca.* 2350 B. C. The upper limit on Isin-Larsa evidence was put to *ca.* 1900 B. C. No definite post-Larsa evidence is available for the Harappan contacts. C^{14} dates, on the other hand, indicate a *ca.* 2300-2000 B. C. bracket for the metropolitan areas and *ca.* 2200-1700 B. C. spread for the peripheral regions.

Fairservis (Fa 61) and Raikes (R 64) had expressed their doubts about the millennium long (*ca.* 2500-1500 B. C.) spread, as noted above. Both did it on independent grounds. Wheeler too, when he proposed (W 62a) *ca.* 2500-1500 B. C. bracket did not emphasise on the terminal dates of his bracket. In fact, Wheeler (W 64) accepting my shorter chronology (Ag 64) admitted that his "bracket may have to be contracted on both the sides." Though recently (W 66) he has again repeated *ca.* 2500 B. C. beginning on the basis (?) of the Sargonid evidence alone. Of course, the end he also puts to *ca.* 1700 B. C. now. He gives (W 66) *ca.* 2500-1700 B.C. in the caption, but in the text he does not mention the basis for 2500 B. C. However, he says, "the Indus civilisation was mature by the time of Sargon dynasty" which may have meant, by inference, that if the mature Harappan is datable to *ca.* 2300 B. C. then, early Harappan may go back to *ca.* 2500 B.C. To support this, Wheeler says, that there is a 70 ft. deposit at Mohenjodaro and "the Mesopotamian contacts of about 2300 B. C. must have come from relatively high levels" (W 66).

Raikes and Dales had first reported the deep silt at Mohenjodaro. Dales explains it thus, "Both the multiple layers of silt at Mohenjodaro and the evidence of multi-level reconstruction suggest that the city was flooded in this prolonged and damaging fashion no less than five times and perhaps more. . . . it seems doubtful that the duration of any one cycle would have exceeded 100 years" (D 66). This, then, could be one of the explanations of the 70′ deposit ! Anyway, one cannot push back the antiquity of a site on the basis of sterile silt deposits. And for these cycles

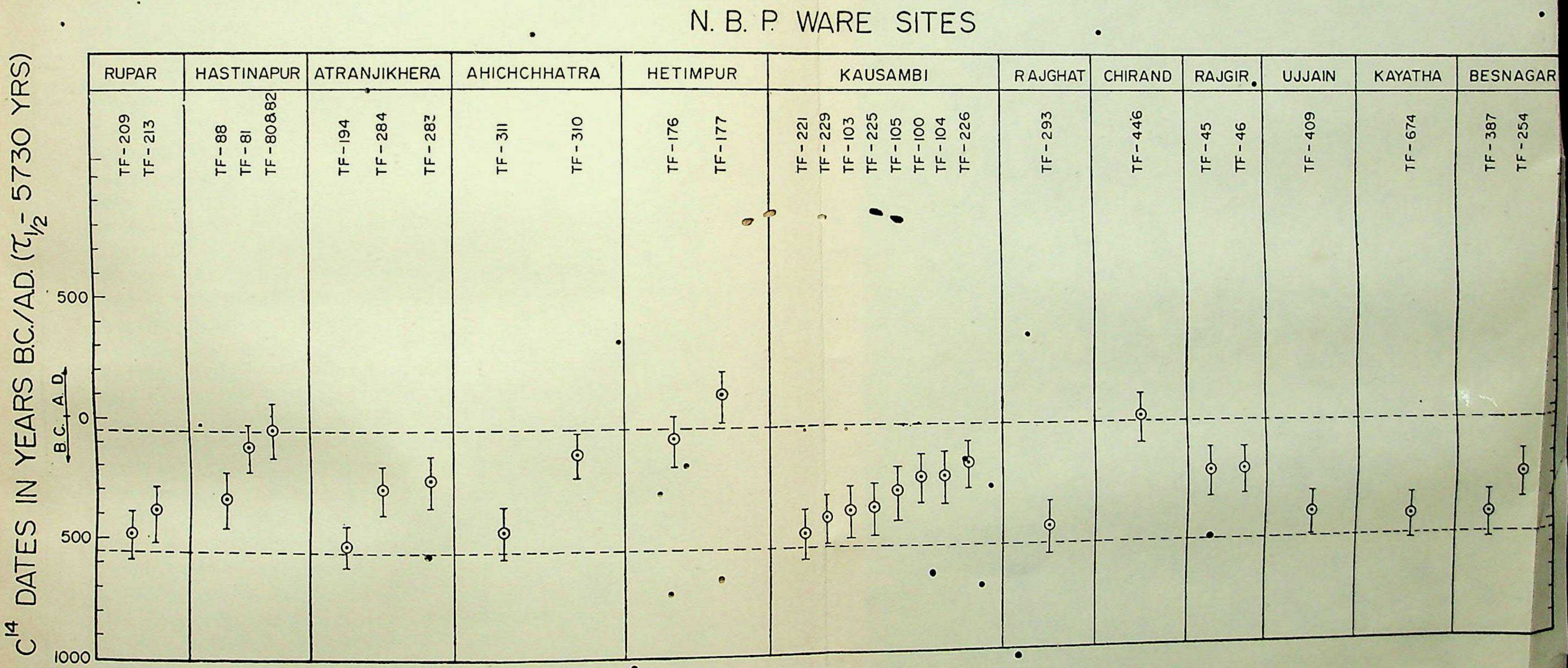

Fig. 9. C^{14} dates from the N.B.P. Ware sites.

of flooding and withdrawal, they give no more than a 500 year duration to the site (D 66).

In the present stage of knowledge, we can only say that the 'early Harappan' is something hypothetical and imaginary. Wherever the Harappa culture comes in contact with the Pre-Harappan cultures, it impinges as a full-blown culture, be it in Kot Diji, Amri or Kalibangan. We had noted in Chapter 2 that though some Pre-Harappan elements contributed to the make-up of Harappa culture, yet it has its own individuality. The Harappan innovations far outnumber the borrowings. It does not look like a derived culture. We really do not know what lies in the lower depths of Mohenjodaro. But a sudden transformation and standardisation of cultural traits in a marketing centre (later developing into cities) cannot be ruled out. And if they built pre-planned cities on fresh ground, where is the chance of seeing the early Harappans under these cities ! If tomorrow, early levels of Mohenjodaro give earlier dates for the Harappans, or the C^{14}/C^{12} variations in the past, when established, push back the antiquity of the Harappans, one will of course have to revise these shorter chronologies. At the moment, however, there is no evidence to push back the Harappan antiquity beyond *ca.* 2350 B.C.

Wheeler, has rightly pointed out that there are no C^{14} dates from the lower levels of the metropolitan Harappan cities. But the C^{14} dates for the Pre-Harappa cultures effectively provide an early limit (Fig. 5). He however admits that *ca.* 2300-1750 B. C. bracket, proposed by me (Ag 64), may be approximately correct "for sites like Kalibangan and Lothal". Allchins (ALN 68) agreeing with the author, in their recent Pelican book, say, ". . . the conclusion that the total time span of this should be between 2300 and 1750 B. C. . . . . appears to us to be on the whole most plausible."

Now most of the scholars like Raikes (R 65), Dales (D 66), Ghosh (G 65), Lal (Lal 62-63) agree with a shorter chronology for the Harappans. Integrating the archaeological and C^{14} dating evidence, I propose timespreads of *ca.* 2350-2000 B. C. for the metropolitan centres and *ca.* 2200-1700 B. C. for the peripheral sites (Fig. 1). One thing is certain, that we have now to discard static views. Wherever the traits of a culture occur, we cannot apply the total time spread to it. For long the Harappa culture was conceived as an Empire spreading a thousand miles on the north-south and similarly on the east-west axes (Fig. 1); and to every site a millennium long spread was affixed. In that period of poor communications, it was impossible to have such 'empires'. In all such cases, we have to trace the epicentres and the secondary sites. The C^{14} dates have clearly shown that the Harappan culture was a shifting phenomenon both in terms of time and space. The implications of this evidence will be discussed in Chapters 7 and 8.

OTHER CHALCOLITHIC CULTURES

While discussing the archaeological dating evidence for the other Chalcolithic cultures, we had noted that most of the western similarities are too scattered—in time and space—to be of any datable value. With Giyan and Sialk III, there are closer parallels, but they cannot be dated beyond *ca.* 1000 B. C. Gupta (Gu 65) is for independent origins of these Chalcolithic cultures. The Kayatha culture, with its unique individuality, may fortify such a probability. Under the circumstances, we will depend on C^{14} dates alone for a reliable chronology of the Chalcolithic cultures.

Roughly, these Chalcolithic cultures lasted for a thousand years (Fig. 7). The three overlapping cultures are Banas, Malwa and Jorwe—in that order. Their total time spread is *ca.* 2000-1100 B.C., in which the Banas culture could have lasted *ca.* 2000-1600 B. C., the Malwa culture *ca.* 1700-1400 B. C. and Jorwe *ca.* 1400-1100 B. C. The pre-iron cultures of Bengal and Bihar show a spread of *ca.* 1300-700 B. C. at the maximum.

The several C^{14} dates now available for the end of Mohenjodaro (Fig. 5) and Pd Ia of Ahar (Fig. 7) place the end of the Harappans in Sind and the emergence of the Banasians in south Rajasthan roughly about the same time, viz., in *ca.* 2000 B. C. The implications of this coincidence will be discussed later (Chapter 8).

B-&-R WARE, P. G. WARE AND N. B. P.

It is interesting to note the relationship of the C^{14} dates and the B-&-R Ware (Fig. 10). The earliest appearance of the B-&-R Ware is in Lothal, next comes Ahar. The C^{14} dates of the B-&-R Ware at Navadatoli and Eran are younger than Ahar. Mahishdal and Rajar Dhibi dates are still younger. These growingly younger C^{14} dates for the B-&-R Ware suggest a dispersal route as indicated in the Figure 10. But the Sunderbans seem to have stopped this route and deflected it to Bihar. Chirand, Sonpur and Rajghat again show growingly younger ages, now from west to east. At Atranjikhera the B-&-R Ware may be pre-1000 B. C., but it did not penetrate deeper into the Doab. The barrier again was possibly the thick forests. The dispersal of the B-&-R Ware technique *vis-a-vis* C^{14} dates does indicate a migratory pattern. This problem will be discussed in detail in Chapters 7 and 8.

Lastly, we would summarise the evidence on the P. G. Ware and N. B. P. chronology. As we discussed earlier, the presence of iron along with the P. G. Ware, the absence of a gap between the P. G. Ware and the N. B. P. and the presence of a definite hiatus between the P. G. Ware and the Harappans at all the excavated sites take away the aura of the antiquity of the P. G.

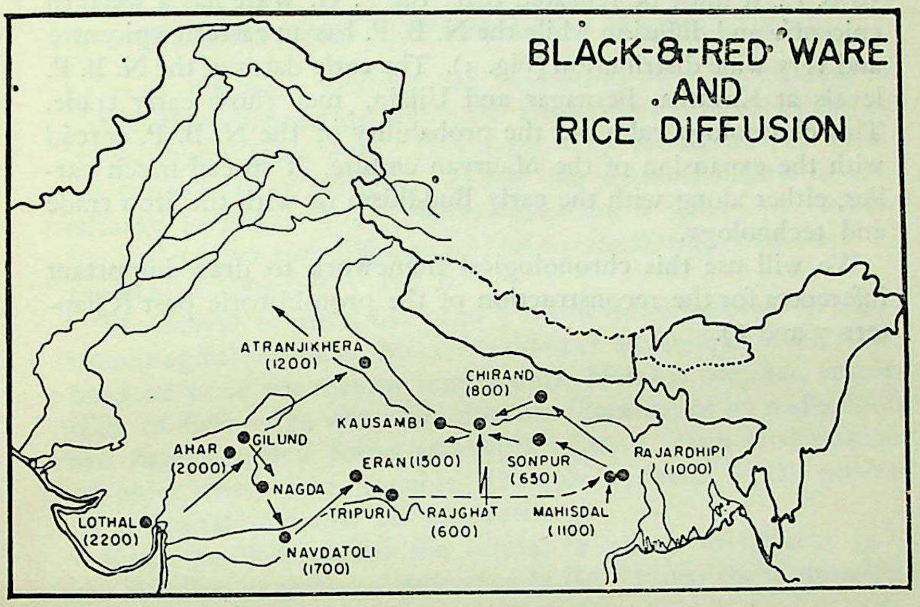
BLACK-&-RED WARE
AND
RICE DIFFUSION
ATRANJIKHERA
(1200)
CHIRAND
(800)
KAUSAMBI
AHAR
(2000)
GILUND
ERAN (1500)
SONPUR
(650)
RAJARDHIPI
(1000)
NAGDA
LOTHAL
(2200)
TRIPURI
RAJGHAT
(600)
MAHISDAL
(1100)
NAVDATOLI
(1700)

Fig. 10. The probable diffusion of the black-and-red ware techniques and rice cultivation, based on C^{14} dates (given in brackets).

Ware. We have noted both Wheeler's and Gordon's views. On the archaeological grounds there is nothing to warrant an older spread for the P. G. Ware than *ca.* 800-500 B. C. Excepting for an anomalous date, TF-191, from Atranjikhera all the other C^{14} dates too suggest a shorter chronology of *ca.* 800-400 B. C. (Fig. 8). Thus a *maximum* bracket of *ca.* 800-400 B. C. should cover the total time spread of the P. G. Ware.

Connected with the P. G. Ware is the chronology of the Iron Age in India. Banerji (Baj 65) sought to associate the advent of iron with the P. G. Ware upper levels. It is quite likely that it took the P. G. Ware people sometime to acquaint themselves with the local ores. A people can bring a technology but not the ores. In any case the iron in the Doab, whether at Hastinapur or Chirand, cannot be dated earlier than *ca.* 800 B. C. (Figs. 7 and 8). But now there is a distinct probability of the Iron Age in the south antedating that of the north with the neolithic-megalithic overlap phase at Hallur dating to *ca.* 1000 B. C. (Fig. 6). Even Palavoy ash mounds are said to be associated with the iron metallurgy.

On the basis of the archaeological evidence discussed, we placed the N. B. P. within *ca.* 550-100 B. C., with its epicentre in Bihar. This estimate agrees well with the C^{14} dating bracket of *ca.* 550-50 B. C. It must be repeated that the P. G. Ware has a western epicentre and diffusion while the N. B. P. has an eastern epicentre and very wide distribution (Fig. 3). The early dates of the N. B. P. levels at Kayatha, Besnagar and Ujjain, may show early trade. This chronology rules out the probability of the N. B. P. spread with the expansion of the Mauryan empire. It spread much earlier, either along with the early Buddhism or with the iron trade and technology.

We will use this chronological framework to draw important inferences for the reconstruction of the protohistoric past (Chapters 7 and 8).

CHAPTER 4

ORIGINS AND DIFFUSION OF METALLURGY

In the previous chapter we examined the archaeological and radiocarbon dating evidence to delineate the protohistoric chronological framework. This framework is essential to assess the probability or otherwise of the independent origins of metallurgy in India. This chapter provides a world perspective for the origins and diffusion of Indian metallurgy, by way of preface to Chapters 5 and 6.

The advent of metal has been a major break-through in man's technological progress. Metal has distinct advantages over stone, bone or wood for making implements. Metal is tougher, susceptible of finer edge and more durable. Because of its malleability and fusibility, new forms and types of tools, even modifications of older ones, were possible. The role of metal in the process of urbanisation needs no emphasis.

Here, we will discuss the origins of copper metallurgy (4.I), the diffusion of technical processes (4.II), as also the terminology of stages (4.III).

Eschewing the static typological approach, we have taken a dynamic and evolutionary view. Biek (Bi 63) has beautifully expressed it, "Even as they observe the same phenomenon—in the same field, at the same level, and from the same angle—different specialists see different things. Some are concerned with the purely static aspect, the morphology and taxonomy of what they see. Others follow the dynamics involved, and though they can only study an instant frozen for examination they look at it as just that, and are ever conscious of changes in equilibria. It is like the difference between architecture and music, painting and poetry. The two approaches are separated by a whole dimension-time. Their stereoscopic fusion may sometimes be more urgent even than the evolution of our ultimate culture which could not in the end, cohere without such dynamic unity."

4. I. *Origins*

The origins of metallurgy are still not clear. However, the native metals were the first to be used by man. Native copper occurs widely. Hammering it into desired shape would have been an easy discovery. But too much hammering would make the tool brittle, and cause cracks and fractures in it. To make it usable again, it has to be heated to red heat. How this property, termed 'annealing', was first discovered can only be surmised. "To throw a broken piece into fire in a fit of temper is an almost instinctive act: to attempt later to salvage a part is equally natural" (Tho 58). The retrieved metal would have been annealed and thus rendered reusable.

Forbes (For 64) distinguished three stages in the evolution of copper metallurgy:

I. Native metal as stones.
II. Native metal stage (hammering, cutting etc.).
III. Ore stage (from ore to metal).

It is important to note here that just occurrence of a metal in an archaeological assemblage is not enough to warrant its inclusion in Copper Age or Iron Age. The terms Copper Age or Bronze Age should be used to denote a specific complex of metal techniques, but not just the use of a certain metal. The use of a specific set of techniques is more specific and characteristic of a period.

The real metallurgy begins with Forbes's stage III, viz. extraction of copper from its ores. Where did this stage first originate ? Aitchinson (A 60) has suggested that the first accidental discovery of smelting from oxide ores could have been made in the following way. In the double tier kilns higher than 1083°C (M. P. of copper) temperature could easily be reached. If malachite, which was used to decorate pottery, was inadvertently placed in a kiln, it could be reduced to copper. This has experimentally been proved by Coghlan. Gowland, however, thought that perhaps the discovery was first made in the camp fires; but the temperature there could not reach these limits.

We must look for the birth place of old world metallurgy in the mountain region stretching from Anatolia through Armenian Mountains eastwards into Afghanistan. The eastern flank is notably rich in the native metals and ores (For 64). Aichinson says (A 60) that the region between the Elburz mountains and the Caspian Sea seems to be the most probable location for the discovery of copper smelting. He places it *ca.* 4300 B.C. This zone was also the home of wild pistachio and *Haloxylon amodendron*, which provide metallurgical charcoal of superb quality. Recent pollen studies suggest that the flanks of the Zagros were forested with wild pistachio during a period that extended from 10,000 to 5,000 years ago (Wer 64).

Some scholars believe in the manogenia theory of the origin of copper metallurgy in north-east Persia in *ca.* 4,000 B.C. (SHH 54). Hegde (He the) seems to take it as an established fact.

Recently Tal-i-Iblis in Mashiz Valley (Kirman Range) has yielded crucibles used for smelting ores, dated to *ca.* 4000 B.C. (CS 66), and thus may be one of the earliest smelting centres.

In Egypt (For 64; Ch 44, 57; A 60) the history of metal is very well documented. In the Tasian period (*ca.* 5000 B.C.) no metal is reported. The Badarians, who probably came from Asia, had a few pins, needles, fish hooks made of native copper. The Amratians (*ca.* 4000 to 3700 B.C.,) had a richer copper repertoire including harpoons, tweezers and chisels; but still all of native copper. Tough malachite and galena occur in the remains, they were not smelted. In the Gerzean period (*ca.* 3600 B.C.), the evidence for contacts with Palestine, Crete and Mesopotamia is available. They are still richer in copper, which is smelted now. The forms are adzes; bracelets; rings and; chisels. The painted pottery too appears first in this period. In Late Pre-Dynastic, (*ca.* 3200 B.C.) times more utilitarian weapons come into being. The types of this period are : daggers; flat axes; tanged spearheads; adzes, knives and; harpoons.

In Mesopotamia the earliest occurrence of smelted copper is from Al 'Ubaid (*ca.* 4000 B.C.) times. During Uruk period copper had come in general use and complicated castings like the socketed axe were successfully made. It may be noted that the sudden efflorescence in metal crafts in the Uruk period accompanies urbanisation, so also in the Harappan period. During Jamdet Nasr period, picks, axes, bowls, rings, tubes, forks and socketed axes of copper appear. Little later, in Khafaje, copper vessels were being deposited in tombs. In the Royal Tombs of Ur of Chaldees, excellent copper repertory has been recovered and in great profusion. Compared to the Harappans, the Sumerians displayed an incredibly high standard in the techniques of working the metals during Early Dynastic Ur. Though Mesopotamian metallurgy is earlier than Egypt, it is little later than Iran.

In Iran from Susa (towards *ca.* 4000 B.C.) copper tools like chisels, needles, mirrors, made from malachite, were recovered. They used open moulds.

4. II. *Diffusion*

Lest we loose our tracks in the hyper-diffusionism of Smith or outright independent evolutionary theories |of Bastion, we would follow Childe and Daniel in their modified approach, "The first concern of prehistoric archaeology was the study of the chronological and spatial position of these layers. It was also, secondarily, the study of their inter-relation if the time space positions permitted such interrelationships" (Dal 64). That is why we first examined the spatial aspect in Chapter 2 and the temporal framework in Chapter 3 to assess the probability of diffusion.

Forbes has repeatedly emphasised the importance of techniques in dealing with metal ages. Simple primary discoveries such as plasticity and malleability may be repeated, but more complex steps of smelting, forging and casting are more likely to have diffused from one or more centres, rather than been repeated at several places.

"The metal itself—copper—diffused more rapidly than the technical knowledge, and hand to hand trading carried copper to far distant regions. . . .The merchants and pedlars have invariably preceded the technologists. . . . The transport of ores to be smelted where they were not mined came at much later dates" (A 60).

In north-west India too the advent of the Bronze Age is quite late. In India it is about two thousand years later than in Iran, as we will see below, despite the unsubstantiated claims to the contrary (Bha 65-66). But the metallurgy of the Copper Hoards seems to have either a south-eastern source or an independent origin (Chapter 6).

In England too the Bronze Age arrived very late. We will first briefly trace the west-ward diffusion from the Iranian epicentres. Then we will trace the eastward course to India.

WESTWARD DIFFUSION

These techniques spread from Iran to Mesopotamia. Above, we briefly saw the development of metallurgy in Mesopotamia. Furtherwest, the metallurgical art diffused to Anatolia and Asia Minor. Troy has given a good sequence of metal working (A 60). In the upper levels of Troy (*ca.* 4000-2800 B.C.) needles and knives of copper appear. In Troy II, bronze (8-11% tin) and more artifacts appear (*ca.* 2800-2300 B.C.). But they did not smelt their own copper, though they were very good metal forgers. During the whole of the IIIrd millennium B.C. Anatolia served as a collecting place for the lore and expertise of Mesopotamia.

Otto and Witter on the basis of their spectroscopic analyses (OW 52) tried to prove independent origins of German copper metallurgy. But this view has been criticised by several scholars (Ch 48; CP 65).

The rapid development of bronze technology in the Near East, from *ca.* 3000 B.C., must have led to an active search for accessible deposits of ore. The barbarian Europe would have presented itself as a Far East of promise to the miner and the prospector. Troy and nearby centres affected the Danubian people more. By 2200 B.C. the Troy traders had reached Vienna and the Erzegebirge in Bohemia (A 60). This technology reached Europe from the Hallspont region, on the mouth of Danube. From Transcaucasia diffusion had started at an earlier date reaching the plains of Hungary. The Central European copper technology may owe more to the contacts established between the Levant and the sources of copper and tin in Tyrol or the Erzegebirge (CP 65).

The westward course then reached Spain and Portugal. By 2500 B.C. a primitive metal culture, entirely based on copper, had been established in the Iberian peninsula. By *ca.* 2200 B.C. the Central Europe became a seller and a buyer of metal goods.

Fresh copper workings were opened up between *ca.* 2200-2000 B.C. in the Carpathian ranges of Transylvania and Slovakia, in the eastern Alps, in the Balkans and extensively in the Erzegebirge mountains of Bohemia and Saxony. In short, a copper based culture was established in large areas of Central Europe. In Great Britain, however, metals do not appear before *ca.* 1900 B.C.; but no pure "Copper Age" ever existed there. The cities in Europe came very much later. Tylecote (Ty 62) says, "In any event, at about the beginning of the second mill. B.C., a group of metal workers with Iberian tradition had settled in Ireland and it was with these people that the Beaker invaders of Southern and Eastern England came into contact."

EASTWARDS DIFFUSION

Unlike the Pre-Harappan cultures of Sind and Baluchistan, the stages in metal technology in Iran can be studied in greater detail. Coghlan (Cog 51) has traced the complete sequence of metallurgical development in Sialk. In the beginning, Pds I and II, copper tools were produced by simple cold hammering. Casting, first in open moulds, was evidenced in Pd III, 4. Closed moulds came into use from Pd. III, 5. In Pd IV smelting and casting techniques by *cire perdue* method are also met with. All these techniques are datable (Pd. I, *ca.* 5000 B.C.; Pd. IV, *ca.* 3000 B.C. onwards) and are thus much earlier than in India.

As noted above, the importance of Tal-i-Iblis, as the earliest known centre of copper metallurgy is crucial for understanding the diffusion of these processes both to the west and the east. Kerman range is very rich in copper ores. Bevelled rim bowls in Tal-i-Iblis of Mesopotamian vintage (*ca.* 2800 B.C.) may show long distance trade in ores or metal (CS 66).

Lamberg Karlovsky (L 67) studied the pottery collected by Stein from Daruyi and Tappa-i-Nurabad, east of Tal-i-Iblis, in the valley of Baluk. He found its close similarities with the pottery of Chah Husseini (Bampur), and Rana Ghundai I and II. These may provide the evidence for contacts and diffusion from this centre to India too.

One does not know exactly how these techniques reached Baluchistan, via Makran or Afghanistan. But as noted before, we will trace these influences from Mundigak with which there is evidence of plenty of contacts. The Phase C (D 65) witnessed the advent of metal in this area which we placed in *ca.* 3300-3000 B.C. From Deh Morasi II Z, Dupree (Dup 63) has reported hollow copper tubes which resemble those from Hissar II levels.

As noted earlier, Mundigak (Cas 61) in Afghanistan offers a complete sequence of metallurgical development. Copper appears in Pd I as evidenced by the presence of elbowed blades (*lame coudee*) and an awl (Pd I, 5). In Pd II_3, appear spear-heads, internally voluted spiral-headed pin and eyed needle. Such spearheads continue to Pd IV. Lamberg Karlovsky (L 67) called it a tanged dagger with midrib, though in the section given, there is no midrib (Cas 61, Fig. 139, 3.). In Pd III_6, tin-alloying also is reported (L 67). But the analyses (Table 23) show that Pd I_5 has higher tin content (0.86 to 1.06%) than that of Pd III_6 (0.6 to 0.77%). Pd III is relatively richer in copper. The tool repertoire includes shaftholed axe and adze (III_6), spearhead without midrib, a sickle blade (?). In Pd IV_3 were found a pin with double voluted head, concave disc (IV_1) fish hook and other likebits, including a lance object with bent blade (IV_2). In Pd V metal finds are not many, mostly they are arrow heads (Cas 61, Fig. 140, 26, 25).

In Baluchistan we hardly get any stratified metal relics. From Isplenji mound 1 (Pak 64) and Quetta some copper artifacts were recovered along with Quetta Ware. Few fragments of copper were found in Damb Sadaat II and III.

In Phase D of Dales are mainly included the Pre-Harappan cultures of Sind, e.g., Kot-Diji, Kalibangan and other sites in Bahawalpur region. From the pre-Harappan levels at Kot Diji only one copper object has been reported (Kh 65). At Amri only metal scraps appear along with a handmade pottery and Togau C sherds. Kalibangan I yielded only two-three pieces. The other sites only suggest some sort of use of copper. From Kulli we got a mirror, pin and flat axe. From Nundara only a bangle is reported.

At Nal a good number of metal tools were recovered from the cemetery and D, and F areas. The types include: knives; blades; bangles; axes etc.

We have thus traced the diffusion from Iran, through Afghanistan and Baluchistan, to Sind. Thus we see that the metallurgical know-how is reaching the Harappans of Sind only about 2300 B.C., more than 1500 years later than west Asia. During the Harappan period there is a sudden efflorescence of copper tools and their variety, as compared to the Pre-Harappan cultures. This obvious diffusionary route, the relatively late date of the Harappans and a full blown metallurgy from the very start preclude any independent origins of metallurgy in the Harappa culture.

Now we will discuss the terminology of stages.

4. III. *Terminology of Stages*

The Poona Seminar on Prehistory (MM 65) was remarkable in many ways. When Thapar (Th 65) read his paper on Neolithic cultures, he was criticised for excluding the Central Chalcolithic cultures from the purview of the paper. Misra (Mi 65) put up a strong plea against making any distinction between the Neolithic cultures and the so-called Chalcolithic cultures. "Once we admit that it is the economy rather than technology which is the diagnostic trait of the Neolithic, all the village sites from the hill valleys of Baluchistan to the southern Deccan will have to be called 'Neolithic', for economically they represent the same stage" (Mi 65).

Of course, he was effectively repudiated by the other participants who held that such a distinction was very much valid, in view of the knowledge of metallurgy available to the Chalcolithic cultures. Childe, who was quoted there both for and against this classification, was atleast against the use of the term Chalcolithic. "The term's use is due to a misapprehension of the whole basis of classification. . . . By the original definition of the Age, any type ever associated in the metal tool or weapon was to be assigned to the "Bronze Age". This should mean that any assemblage or culture in which recognizable *local* metal types occur, however, rarely, is to be classified in the Bronze Stage" (Ch 56). The point to be taken note of is that they should be *local*. He was categorical, "Occasional imported metal objects, evidently the products of a metallurgical industry in another province, do not justify the attribution of the local assemblages in which they occur to a local Bronze Age. Thus stray Irish halberds or Bohemian pins, imported into Denmark or South Sweden, do not make the graves in which they occur 'Bronze Age'" (Ch 56).

For us, a definite classification of the Pre-Harappan cultures of the north-west under Chalcolithic or Neolithic would not be possible at the present stage of knowledge. Dales' (D 65) classification in phases, denoted by alphabets, is the best tentative classification at the present state of knowledge. But for the Neolithic sites of India, despite a trickle of metal mostly in the upper levels of a few sites (e.g. Brahmagiri, Piklihal, Tekklakota), we can safely exclude them from the purview of the Chalcolithic cultures in India. These objects are more in the nature of import of luxury goods rather than their own local manufacture. The Chalcolithic cultures, on the other hand, had the knowledge of metallurgy. It was pointed out by me (Ag 65) that "on chronological, technological, as also economic grounds, it is obvious that the Chalcolithic cultures, of central and western India do not belong to the pure Neolithic phase". For example, if we compare Brahmagiri and Ahar, we can see the glaring contrast. At Brahmagiri, only one copper chisel and two rods were found from the extensive excavations, whereas the stone tools were legion. But in Ahar, no stone tools were met with, though four copper celts, bangles, sheets etc., besides definite evidence of copper smelting, were attested to. The sophisticated wheelmade Chalcolithic pottery —in contrast to the hand-made Neolithic wares—too reflects the presence of the specialised craftsmen in the society.

Coming back to Childe, he accepted that Thomsen's "Three Ages are everywhere demonstrably homotaxial. It does not, however, follow that all societies assigned to any one of them were systadial in an imaginary process of unilineal social evolution. Still less were such societies contemporary. It might be wiser to replace the word 'Age' by 'State'" (Ch 56).

The term Bronze Age has quite often been used. But it may most often be chemically incorrect, as without the evidence of deliberate alloying, we are not justified in using the term. Childe's compromise term for this was : "Palaeometallic Stage".

But the terms that come in vogue once have a tenacity and are not easy to change. The classic example is the Northern Black Polished Ware, which is neither black, nor polished, nor even northern.

Here too, a conference on standardisation of Indian archaeological terminology is a desideratum.

Childe (Ch 56) realised the implications of the term Bronze Age which "indicates not only the approximate position of a culture in a sequence but also suggests a good deal about its technical potentialities—not only the mastery of metallurgy, but also the possibility of making things demanding metal tools such as wheels—something of its economy—at least trade—and even of its sociology, the existence of full time specialists". This concept would be followed by us too. And we will discuss it further later.

In his stimulating Huxley Memorial lecture Childe (Ch 44) tried to find an order in the stages of the use of metal in a given culture. He used the term 'mode' because that obviated any implication of synchrony or homotaxy in different provinces. He distinguished four modes:

Mode O : When copper was used more or less as stone for chipping, grinding, bending and hammering.

Mode I : Weapons and ornaments were made from copper and its alloys, but no mutant tools and hardly any implements adapted exclusively to industrial use. On the other hand, stone tools including celts were still made, and generally with as much care as in the Neolithic.

Mode II : Copper and bronze were regularly used in handicraft, but not in husbandry, nor for rough work. The metal types include knives, saws and specialised axes, adzes and chisels. On the domestic sites, ground stone celts, flint blades and similar implements were abundant.

Mode III: Metal is used in agriculture for rough work. It is symbolised in the archaeological record positively by the production of metal sickles, hoe blades or even hammer heads and negatively by a certain decline in the lithic industry, but not by its complete suppression.

It appears that in later years, Childe did not insist on this classification as it was much too dependent on functional aspect of tools. It will not be easy to categorically say that Mode II tools were never used for agriculture. Typical sickles are absent in Indus too, but various types of knives could have been used for the purpose. Many so-called chisels and bar celts could have been hoes, for all we know. Though, the far-reaching role of metal in the economy has yet to be realised.

Forbes (For 64) on the other hand emphasised the importance of techniques as criteria for distinction of periods, as briefly noted before. "Once we start using the metal techniques of a certain period as a criterion, and no longer, the kind of metal or alloy used, we see that the development in every region becomes a succession of stages of phases each of which are complete in themselves."

Copper and Bronze Age, he said, should be used to denote a specific complex of metal techniques. The use of specific set of techniques such as casting, annealing and embossing are more specific of a particular archaeological period than the native metal, extracted metal and alloy that happens to be favoured during a certain period.

To counterbalance the above we would quote Childe (Ch 57) again, "The use of metal tools does not depend simply on technical knowledge. . . . A community can only use metal tools when it is producing an effective social surplus. In each case the threshold is determined by economic and social factors—the efficiency of rural economy and the concentration, or at least fluidity of the social surplus. In the second place, metallurgy (etc.) were crafts exercised by full time specialists. Such were at least economically released from kinship bonds : their mysterious skills could earn them a livelihood wherever the social surplus was available".

It is obvious from the foregoing that the occurrence of mere metal in an archaeological assemblage does not qualify it to full metal age. It is the knowledge of particular metallurgical techniques and their role in various economic industries that are more determining. For example, in the Indian context, presence of a few iron tools should not automatically bring in the Iron Age (Ta 67-68). In any discussion of the Iron Age, one should know whether the tools were locally manufactured, from which ores, whether carburisation to make steel was known, quenching was known or not and finally what transformation the advent of metal brought about in a particular culture. At the moment the only available comprehensive book on the Iron Age in India (Baj 65) does not bother to answer any of these crucial technological questions.

In the following discussions, I would use an integrated approach in which the techniques known to a given culture will determine both its status in the evolution of cultures in a given area, as also help to distinguish it from the other cultures. We will try to see for example, what metal techniques were known to the Harappans, to the other Chalcolithic cultures and to the Copper Hoard people. The chemical data would be used to distinguish various assemblages, as also to determine the ores used, to the extent possible.

On the basis of the knowledge of alloying and greater specialisation in society, I propose that atleast the Harappa, the Banas, the Malwa, the Jorwe and the pre-Iron cultures of the east be included under the Bronze Age. Though I have not used any new terminology of Ages in the present work as that requires more data and collective discussion. I will use the same categories, as used before in this book:

(I) Pre-Harappan Culture
(II) Harappa Culture.
(III) Other Chalcolithic Cultures and Copper Hoards.
(IV) P. G. Ware Culture.

I have used the term 'Chalcolithic Culture' for all these cultures to the exclusion of the Harappans. The only merit in following this practice is that the Indian archaeologists are used to this terminology.

However, I would take the total assemblage into account, as also the techniques used. For the concluding synthesis, I would try to determine the state of economy, its place in time and the ecological setting too.

Generalisations would require much more work of the type attempted here.

CHAPTER 5

CHEMICAL ANALYSIS

THE IMPORTANCE OF chemical analysis of metal artifacts for archaeological purposes has not been very well recognised in our country so far. In the beginning some attempts were made to trace the sources of Indus copper, but were left half way. The problems of the Indus copper, the status and affinities of the Copper Hoards, the origins of the other Chalcolithic cultures can largely be solved if an extensive project of artifact and ore analysis is taken up. In Europe already such work* has thrown light on the centres of manufacture, using both westerly (Iberian) ores and those of eastern (Transylvania) types, as well as others including a Hiberno-British group and an East Alpine source. It has been shown that certain cultures and certain chronological phases can be equated with the use of specific metal sources. The existence of a Copper Age in Europe before the discovery of bronze, has been confirmed (CP 65; BRi 63). All this indicates the immense potentialities of such work in the Indian context too.

In the West the significance of chemical analysis was realised long back. In England, British Association's Sumerian Copper Committee was founded in the early twenties. Professor Desch carried out a large number of analysis for this Committee and the results (including those for Harappan artifacts) were published in the Reports of the British Association for the Advancement of Science (BAAS 28, 29, 30, 31, 33, 35, 36).

I will discuss all these topics under the following headings:

5. I. *Problems and Approach*
- A. Sumerian Committee
- B. Work in India
- C. Work Abroad.
- D. Native Copper
- E. Summary and our Approach

5. II. Ores and Smelting.

5. III. Alloying

5. IV. Ore-Correlations

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* In Europe and England a great deal of research is being carried out on the prehistoric metallurgy. Junghans, Sangmeister and Otto in Germany, Pittioni in Austria, Coghlan in U.K., Oldberg in Scandinavia, Pleiner in Czechoslovakia are some of the leading workers. The work in this field by Institutions like University Research Laboratory for Archaeology, Oxford, Pitt Rivers Museum, Ancient Mining and Metallurgical Institute, London, National Argonne Laboratory, U.S.A., is stupendous indeed.

F. 16

TABLE 6
Percenatge Composition

Sites : Ur and Kish

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Reference
Ur										
1. Royal Cemetery	—	1.71	—	—	1.13	—	85.13	11.78	0.25	(Bu 51)
2. ,,	—	—	—	—	0.47	—	85.01	14.58	—	,,
3. ,,	—	0.15	—	—	0.43	—	70.24	11.1	0.59	,,
4. Spear—U 12239 B.M.L.III	—	Tr.	—	—	Tr.	—	97. 2	0.56	1.36	,,
5. Axe U 12098 B.M.L. XVI	—	Tr.	—	—	0.22	—	87.93	11.65	0.20	,,
6. Sargonid object	—	Tr.	—	—	—	—	72.19	2. 4	0.12	,,
7. Details not given	—	0.03	—	—	Tr.	—	94.41	—	1.17	,,
Kish										
8. Kish Pd. A.	—	1.31	—	—	0.58	—	94.01	0.43	3.34	,,
9. Kish (3200 B.C.) thin metal	—	0.15	4.6	—	—	—	95.17	—	0.08	,,

TABLE 7

Percentage Composition

Sites : Ur, Kishand Bahrein

	Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	S	Reference
1.	Ur A	—	—	—	—	1.62	—	84.18	12. 0	2.20	—	(Bu 51)
2.	Ur B	—	1.74	—	—	1.13	—	85.13	11.78	0.25	—	,,
3.	Ur C	—	—	—	—	0.47	—	85.01	14.25	Tr	—	,,
4.	Kish 156693	—	—	—	—	—	—	57.12	8.21	0.05	—	,,
5.	,, 156835	—	—	—	—	—	—	67.46	8.60	0.05	—	,,
6.	,, 156688	—	—	—	—	—	—	68.40	10.70	0.17	—	,,
7.	,, 156796	—	—	—	—	—	—	80.30	2.52	0.09	—	,,
8.	,, 156700	—	—	—	—	—	—	64.42	5.83	0.02	—	,,
9.	,, no number	—	—	—	—	—	—	78.12	5.17	0.005	—	,,
10.	,, A mound	—	1.31	—	—	0.58	—	94.01	0.43	3.34	0.17	,,
11.	,, W mound	—	6.16	—	—	0.15	—	88.16	4.65	Tr	0.42	,,
12.	Tell-el-Obeid Lion piece	—	0.98	—	—	—	—	98.81	Tr	0.12	0.09	,,
13.	Tell-el-Obeid Nail	—	0.25	0.02	—	—	—	99.21	0.16	0.23	0.12	,,
14.	Iraq nail (*ca.*2000 B.C.)	—	0.28	Tr	—	0.68	—	88.60	9.77	—	0.17	,,
15.	Bahrein Island Tomb No.5 (*ca.* 1200 B.C.)	—	0.53	—	—	0.27	—	89.07	9.60	—	0.53	,,
16.	,, ,, ,, No. 6	—	0.54	Tr	—	—	—	87.76	11.70	—	—	,,
17.	,, ,, ,, No. 3	—	0.44	—	—	0.47	—	94.69	3.18	0.27	0.95	,,
18.	,, ,, ,, No. 7	—	0.94	—	—	1.40	—	77.53	19.29	0.52	0.34	,,
19.	,, ,, ,, No. 8	—	0.75	—	—	Tr	—	82.16	16.57	—	0.52	,,
20.	Copper nail from Sumerian statue	—	0.86	—	—	—	—	95.07	—	0.28	—	,,

TABLE 8

Percentage Composition

Sites : Ur and Khafaje

Sample details	As	Pb	Cu	Sn	Ni	Reference
Early Dynastic : Khafaje						
1. Kh II 75 Arrow bit	0.47	—	74.22	—	0.06	(BAAS 35)
2. Kh II 80 Nail head	0.38	—	79.93	—	0.02	,,
3. Kh II 87 Graver	0.64	0.86	67.10	4.34	0.009	,,
4. Kh III 44 Dagger	0.94	—	89.99	2.98	0.30	,,
5. Kh III 215 Pin	1.06	—	88.98	3.44	0.09	,,
6. Kh III 688 ,,	0.83	—	94.45	0.32	0.07	,,
7. Kh III 729 ,,	—	Tr.	53.73	3.33	0.03	,,
8. Kh III 850 ,,	0.68	—	87.50	10.64	0.09	,,
9. Kh III 904 Blade	0.23	—	83.22	9.82	0.16	,,
10. Kh III 1027 Pierced pin	1.80	—	93.63	0.29	1.42	,,
11. K. 319 Pin	—	—	83.37	1.31	0.02	,,
12. K. 344 Lump	Tr	—	80.63	—	0.06	,,
13. 1296 Dagger blade	0.94	0.22	49.82	0	0.29	(BAAS 33)
14. 465 Rolled Pin	0	Tr	39.70	0	0	,,
15. 187 Rolled Pin	0.22	0	77.98	0	Tr	,,
16. 152 Lamp	0.90	0	78.73	6.31	0.22	,,
Jamdet Nasr Period : Ur						
17. Sample No. I	0.65	—	48.18	—	Tr	(BAAS 35)
18. ,, ,, II	0.20	—	55.59	—	0.02	,,
19. ,, ,, III	0.39	—	55.66	—	—	,,
20. ,, ,, IV	0.93	—	67.23	—	0.075	,,
21. Copper rod	0.34	—	82.33	—	0.05	,,

5. I. *Problems And Approach*

To appreciate the problems involved and the approach used by me, the work in this field, often contradictory, has to be scrutinised first. I will state the positions of the various workers and give my comments in brackets. Sections I and II give the background evidence and discussions; my observations and data are included in sections III and IV; the probability calculations are given in the tables.

I. A. SUMERIAN COMMITTEE

It will be useful to start with the Sumerian Committee's work and the difficulties faced by them in ore-correlations.

Right from the beginning Desch thought that the nickel content of the Mesopotamian ores would lead him to the source of ore. The chemical analyses of Ur, Kish, Tell-al-Ubaid (Tables 6, 7, 8) would show that nickel is present in the Mesopotamian copper artifacts. On the other hand most of the Egyptian coppers were pure (Table 9) and did not contain nickel or gold. The ores from Persia, Black Sea region, Sea of Marmora, Cyprus, Egypt and Sinai* were shown to be free of nickel (BAAS 28, 33). In later reports even Transvaal ores of high nickel content were mentioned, but they are impossible sources for Mesopotamia. The references to Magan as the source of copper, diorite and dolerite, may help us identify it with Oman. From Oman, Jabal-al-Maadan, in Wadi Ahin, both ore and slag were analysed. The slag had little copper and no nickel. The thin veinform ore, contained 1.5% copper and 0.19% nickel. This then was thought to be the source of Mesopotamian copper (Pe 28). But there are several other mines (Fig. 11) e.g., in Armenia, Anatolia and Kastamonu, where too the ores contained nickel. Thus the original theory that the Sumerians used Oman nickel-content-ore was disapproved by further data. Nor is there any unanimity about the identification** of Magan with Oman.

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* Ingot from Bir Nasb, Sinai gave:

	Cu	Sn	Ni	Fe	Pb	S	AS
	%93.01	—	—	5.91	—	—	0.08

** Even in Oman, Peake identified it with Jabal-al-Maadan (Pe 28) but Langdon with Jabal Akhdar. Jacobson equated it with Egypt. Weidner suggested that it was to be identified with Arabian foreshore. Ilya Gershevitch's work has decisively proved on the basis of old records of trade in sissoo wood that Magan and Meluhha lay on the trade route to India. Magan may be the Zagros mounts and mines of Persia (Mal 65). Magan in pre-1500 B.C. period was, some scholars believe, identified with Baluchistan, and after that with Egypt. Though Kramer (Kr 63) refuses to believe in any shift in toponymy.

TABLE 9

Percentage Composition

Based on (Bu 51)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn
1. Egypt Dynasty I	—	0.1	0.4	—	Tr	—	99.5	—	—	—
2. ,, I	—	—	—	—	—	—	100	—	—	—
3. ,, I	Tr	Tr	—	—	—	—	99.9	—	—	Tr
4. ,, I	Tr	Tr	0.3	—	—	—	98.0	—	—	Tr
5. ,, I	—	—	Tr	—	—	—	98.1	—	—	0.3
6. ,, I	—	0.5	—	—	—	—	97.0	—	0.4	—
7. ,, I	0.005	0.03	0.2	0.2	0.2	.004	balance	0.001	0.01	—

Early Mesopotamian copper was generally very pure (Table 10). The Susa axe-head, except for a trace of nickel, was remarkably pure. The Sumerian Committee analysed ores from Arghana and Angora to see if they were probable sources:

	%Copper	Tin	Iron	Nickel	Sulphur
Angora ore	99.83	Trace	0.17	—	—
Arghana ore	97.08	0.27	2.13	0.03	0.49

Though Arghana ore is nearer, it is not pure enough for Susa-axe. Desch says, "it is very likely that the pure metal has been obtained by smelting malachite, a mineral of such characteristic appearance that it would be easily recognised by early metallurgists, and often of high purity" (Pe 28). Thomson (Tho 58) also holds that uptill *ca.* 2500 B. C. only malachite, an oxide ore, (Table 10) was used. It is interesting to note here (to anticipate) that the Central Indian Chalcolithic cultures seem to have used oxidised ores of

TABLE 10

Percentage Composition

Based on (Tho' 58)

	Copper	Tin	Iron	Nickel	Sulphur	Lead	Arsenic	Zinc	Bismuth	Antimony	Silver
I Native copper	(99.96)	0.0005	0.0002	0.03	—	n.d.	n.d.	n.d.	n.d.	n.d.	0.0025
II Early Third Millennium (Malachite ?)	(99.43)	0.02	0.3	0.005	—	0.002	0.1	0.005	0.0005	0.03	0.1
III Middle Third Millennium (Malachite ?)	(99.7)	0.03	—	0.002	—	0.01	0.2	0.005	0.002	0.03	0.01
IV Later Third Millennium (Weathered Pyritic ore ?)	(98.98)	0.5	0.1	0.03	—	0.03	0.3	—	0.006	0.05	0.01
V Later Third Millennium (Pyritic ore?)	(97.41)	0.87	0.02	0.16	—	0.56	0.2	—	—	—	—

Showing the increase in the impurity content of the West Asian copper artifacts with the use of pyritic ores.
Key: n.d. = not detected spectrographically. Figures for copper in brackets are by difference.

high purity. The addition of lead seems to be deliberate for better fusibility.

[From the foregoing it is evident that nickel was thought to be the only crucial element by these workers in locating the ores and despite the monumental work of the Sumerian Committee, it did not lead us anywhere. I may mention here that nickel is present in ancient West Asian and Egyptian artifacts too, as shown below; and is in no way distinctive of the Harappans.]

TABLE 11

Sites	Total No. of tools	With Nickel	With Arsenic
Egyptian	30	8	22
Khafaje	16	14	13
Ur	16	15	14
Kish	10	10	1

Several Harappan samples too were analysed by the Sumerian Committee besides the ores from many regions. On the basis of the presence of lead in the Harappan tools (Tables 13 and 14) they thought that probably the Baluchistan ores were used, as there were no ores in Sind. But the analysed Baluchistan copper ores did not show lead (BAAS 31):

Koh-i-lar, Baluchistan ore No. 1—Copper 42.76%; Nickel trace
Koh-i-lar, ,, ,, No. 2—Copper 16.8%; Nickel absent

In the beginning, even nickel was not reported to be common in the Harappan artifacts. In fact Desch (BAAS 29) said that out of the 64 artifacts analysed, 20 contained upto 1.49% nickel (more common percentage was upto 0.3% only), but most of them were free of nickel.

I. B. WORK IN INDIA.

SANAHULLAH (San 40) analysed 48 specimens from Harappa and tabulated them on the basis of the presence of arsenic, nickel and lead:

TABLE 12

Arsenic %	No. of tools	Nickel %	No. of tools	Lead %	No. of tools
0-0.3	19	0-0.2	22	nil	15
0.3-0.5	5	0.2-0.5	18	0-0.5	14
0.5-1.0	10	0.5-1.0	6	0.5-1	12
1-2	7	1.0-1.5	2	1-3	4
2-7	7			3-5	2
				32	1

TABLE 13

Percentage Composition

Site : Mohenjodaro Early levels

Key : Tr=trace.
+ = present.
(Analysed by the Sumerian Committee)

Sample	details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	REL. PROB. % I	II	III	Reference
D.K.	9474	—	1.08	—	—	Tr	—	98.02	—	Tr	8.0	84.0	8.0	(M 37-38)
,,	9476	—	Tr	—	—	Tr	—	100	—	—	47.0	51.0	2.0	,,
,,	9477	—	1.4	—	—	Tr	—	98.6	Tr	Tr	8.0	84.0	8.0	,,
,,	9478	—	Tr	—	—	Tr	—	100	Tr	—	47.0	51.0	2.0	,,
,,	9483	—	—	—	—	—	—	100	—	—	,,	,,	,,	,,
,,	9497	—	0.76	—	—	1.37	—	82.87	15.0	Tr	1.0	92.0	7.0	,,
,,	9503	—	—	—	—	—	—	100	—	—	47.0	51.0	2.0	,,
,,	9509	—	0.70	—	—	Tr	—	98.9	—	0.4	16.0	77.0	7.0	,,
,,	9514	—	1.4	—	—	3.0	—	86.3	12.3	Tr	—	93	7.0	,,
,,	9531	—	Tr	—	—	3.6	—	90.1	3.3	Tr	5.0	92	3.0	,,
,,	9548	—	Tr	—	—	Tr	—	88.5	11.5	Tr	47.0	51.0	2.0	,,
,,	9549	—	4.1	—	—	Tr	—	92.8	1.2	1.9	47.0	51 .	2.0	,,
,,	9555	—	2.2	—	—	Tr	—	97.2	—	0.6	8.0	84	8.0	,,

Contd.

D.K.	9562	—	Tr	—	—	Tr	—	100	—	Tr	47.0	51.0	2.0	(M 37-38)
,,	9567	—	Tr	—	—	Tr	—	73.1	26.9	,,	,,	,,	,,	,,
,,	9583	—	Tr	—	—	—	—	100	Tr	Tr	,,	,,	,,	,,
,,	9460	—	—	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9472	—	—	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9734	—	Tr	—	—	Tr	—	100	—	Tr	,,	,,	,,	,,
,,	9740	—	Tr	—	—	Tr	—	87.77	12.0	0.23	,,	,,	,,	,,
,,	9742	—	Tr	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9744	—	Tr	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9765	—	Tr	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9767	—	Tr	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9770	—	Tr	—	—	—	—	99.30	0.70	Tr	,,	,,	,,	,,
,,	9784	—	Tr	—	—	—	—	100	—	—	,,	,,	,,	,,
,,	9789	—	Tr	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9808	—	Tr	—	—	—	—	99.18	Tr	0.82	,,	,,	,,	,,
,,	9825	—	Tr	—	—	Tr	—	91.49	8.3	0.48	,,	,,	,,	,,

Contd.

TABLE 13 (Contd.)

Sample	details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	REL. PROB.%			Reference
											I	II	III	
D.K.	9828	—	Tr	—	—	—	—	100	+	—	47	51	2	(M 37-38)
,,	9682	—	Tr	—	—	—	—	99.4	0.6	—	,,	,,	,,	,,
,,	9714	—	Tr	—	—	—	—	100	+	—	,,	,,	,,	,,
,,	9715	—	Tr	—	—	Tr	—	99.63	Tr	0.37	,,	,,	,,	,,
,,	9722	—	Tr	—	—	0.86	—	76.19	22.2	0.75	5	92	3	,,
,,	9728	—	Tr	—	—	Tr	—	99.75	Tr	0.25	47	51	2	,,
,,	9366	—	1.1	—	—	6.3	—	87.7	4.9	Tr	0	92	8	,,
,,	9368	—	Tr	—	—	—	—	100	—	Tr	47	51	2	,,
,,	9376	—	Tr	—	—	Tr	—	100	—	Tr	,,	,,	,,	,,
,,	9392	—	Tr	—	—	—	—	86.3	13.7	Tr	,,	,,	,,	,,
,,	9421	—	Tr	—	—	Tr	—	100	—	Tr	,,	,,	,,	,,
,,	9442	—	Tr	—	—	14.9	—	63	22.1	Tr	2	97	1	,,
,,	9446	—	Tr	—	—	Tr	—	99.04	—	0.96	47	51	2	,,
,,	9457	—	—	—	—	—	—	99.66	—	0.34	,,	,,	,,	,,

Site : Mohenjodaro

TABLE 14

Percentage Composition

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	S	O_2	REL.PROB.% I	II	III	Reference
Copper Lamp	—	0.03	0.15	0.88	0.02	—	96.67	—	1.27	0.98	—	0	19	81	(Mar 31)
,, ,,	—	0.49	—	0.98	Tr	—	97.07	—	0.31	1.15	—	5	31	64	,,
,, ,,	—	—	—	—	0.09	—	96.42	—	0.35	0.36	2.78	1	98	1	,,
,, ,,	—	1.51	1.30	Tr	Tr	—	92.49	0.37	1.06	Tr	1.01	4	53	43	,,
Fragments of implements	—	0.12	0.74	0.72	1.58	—	95.80	—	0.25	0.61	0.18	0	6	94	,,
Celt	—	0.15	4.42	—	0.26	—	94.76	0.09	0.14	—	—	0	3	97	,,
Copper Chisel	—	0.59	3.42	0.10	3.28	—	92.41	—	0.15	0.05	—	0	18	82	,,
Bronze Rod	—	0.15	1.96	1.15	0.17	—	91.90	4.51	—	0.16	—	0	1	99	,,
Bronze Buttons	—	0.29	Tr	2.60	—	—	88.05	8.22	Tr	0.84	—	5	11	84	,,
Bronze Chisel	—	0.35	—	0.35	0.70	—	86.22	12.38	—	—	—	0	34	66	,,
Bronze Slab	—	0.42	1.17	0.33	0.11	—	82.71	13.21	0.56	—	1.49	0	5	95	,,
Bronze Chisel	—	0.18	0.07	Tr	Tr	—	85.37	11.09	0.16	0.11	3.02	6	61	33	,,
Bronze Lamp	—	—	—	Tr	0.17	—	83.92	12.13	0.17	—	3.61	5	84	11	,,

He noted that nickel is generally below 0.5% and seldom 1%, but the proportion of arsenic is relatively high and at times excessive. Sumerian copper also contained similar proportions of nickel, but he said that it could be distinguished from the Harappan by its virtual freedom from arsenic.

It has been found that the ores from Khetri, Alwar, Singbhum and Afghanistan contain both nickel and arsenic, while those from Bilaspur and Nellore are entirely free of nickel.

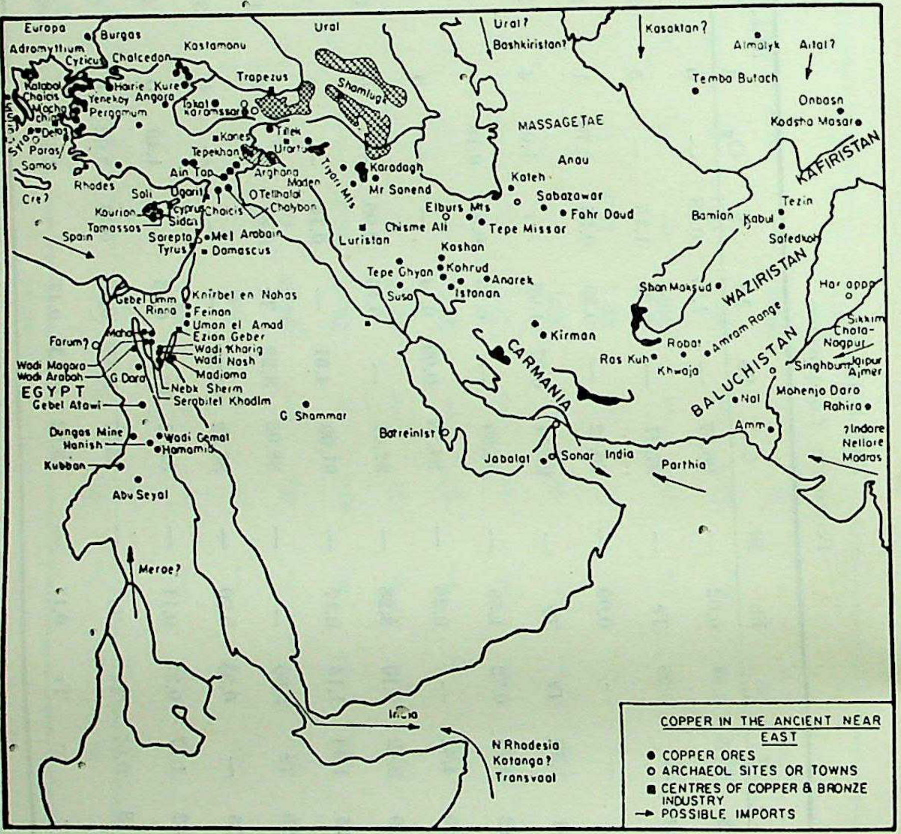

Europa
Burgas
Adromyttium
Cyzicus
Chalcedon
Kostamonu
Ural
Ural?
Bashkiristan?
Kasaktan?
Almalyk
Altai?
Temba Butach
Onbasn
Kodsha Masar
Kalabol
Chalcis
Harie
Kure
Yenekoy
Angora
Tokal
Karamssar
Trapezus
Shamlug
Pergamum
Mocha
Delos
Syra
Paros
Samos
Kones
Tilek
Urartu
Tepekhan
Ain Tap
Arghana
Maden
Tiyari Mts
Karadagh
Mr Sanend
MASSAGETAE
Anau
Kateh
Sabazawar
Fahr Daud
KAFIRISTAN
Rhodes
Cre?
Soli
Ugarit
O Tellhalal
Chalybon
Kourion
Cyprus
Chalcis
Tamassos
Sidon
Sarepta
Mel Arabain
Tyrus
Damascus
Spain
Elburs Mts
Chisme Ali
Tepe Missar
Luristan
Kashan
Tepe Ghyan
Kohrud
Anarek
Susa
Istanan
Bamian
Kabul
Tezin
Safedkoh
WAZIRISTAN
Shan Maksud
Harappa
Gebel Umm Rinna
Knirbel en Nahas
Feinan
Uman el Amad
Ezion Geber
Wadi Kharig
Wadi Nash
Madiama
Nebk Sherm
Serabitel Khadim
Maghara
Farum?
Wadi Magara
Wadi Arabah
G Dara
EGYPT
Gebel Atawi
G Shammar
Kirman
CARMANIA
Ras Kuh
Robat
Amram Range
Khwaja
BALUCHISTAN
Sikkim
Chota-Nagpur
Singhbum
Jaipur
Ajmer
Mohenjo Daro
Rahira
Nal
Amm
?Indore
Nellore
Madras
Dungas Mine
Hanish
Wadi Gemal
Hamamid
Kubban
Abu Seyal
Batreinist
Jabalat
Sonar
India
Parthia
Meroe?
India
N Rhodesia
Katanga?
Transvaal
COPPER IN THE ANCIENT NEAR EAST
● COPPER ORES
○ ARCHAEOL SITES OR TOWNS
■ CENTRES OF COPPER & BRONZE INDUSTRY
→ POSSIBLE IMPORTS

Fig. 11. Distribution of Copper Ores in West Asia.

[I would say that though in Kish (Table 7) arsenic is rare, in Khafaje and Ur about 88% artifacts contain arsenic (Table 8) and hence this cannot be used as a safe criterion for distinguishing the Mesopotamian from the Indus copper.]

LAL (in Lal 51) analysed an anthropomorphic figure from Bisauli and found 0.66% nickel (copper—98.77%) in it. On this basis he said that "the small amount of nickel detected in the specimen represents an impurity derived from the copper ore. The fact is significant, as it shows that the ore from which the metal was smelted was of Indian origin. The Indian copper ores have generally arsenic or nickel or both as impurities, and these are considered the key elements in placing the source of raw material".

We have already seen (Tables 7 and 8) that nickel is not peculiar to India, but quite common in Mesopotamian artifacts too. Therefore, on the basis of nickel alone we cannot ascribe Indian origins.]

P. C. RAY also followed Sanahullah's views. "The presence of lead in some of the copper objects is also noteworthy. Copper ores associated with lead occur in Rajputana and in Hazaribagh district, as also in Afghanistan and Baluchistan. Samples of copper ores from Khetri, Alwar and Singhbhum and Afghanistan contain both nickel and arsenic, while those from Bilaspur and Nellore are entirely free from nickel. It can therefore be concluded that Indus Valley copper most likely came from the Indian ores in the Rajputana district and Baluchistan, though Afghanistan and Persian sources cannot be ruled out" (Ray 56). Bhardwaj (Bh 65-66) too follows Ray.

[The approach, as we will see later, is over-simplified.]

HEGDE, being a young worker with knowledge of the modern work done abroad, realised (He the) the complexity of the problems of ore correlations. "When copper is smelted from an ore, normally elements like gold, silver, tin, nickel, lead, cobalt, bismuth pass on to the constitution of the extracted metal, if these elements are present in the copper ore smelted, without much loss in their quantity, during the smelting process. Elements like iron, manganese, zinc, aluminium, chromium, molybdenum, vanadium, gallium, zirconium, tungsten, and titanium will also pass on to the constitution of the extracted metal, if they are present in the ore smelted. The difference between the former set of elements and the latter is that while the elements in the former set pass on to the extracted metal quantitatively without much loss during the smelting process, the elements of the latter set, pass on to the extracted metal with considerable loss in their quantity; often they are present in the extracted metal only in minute traces."

"Apart from these (two sets of) elements, elements like phosphorus, silicon, calcium, arsenic, sulphur and antimony also at times pass on to the extracted metal, if they are present in the copper ore smelted" (He the).

He compares the impurity patterns of Ahar artifacts and Khetri ore on the basis of spectroscopic analyses and finds close parallelism. Absence of gold also, in his view, confirms the derivation of Ahar artifacts from Khetri ores.

[The comparison of impurity patterns of ores and artifacts is a useful indicator, but for any valid conclusions much more data are required.]

I. C. WORK ABROAD

Several groups have been engaged in the metallurgical analysis of ancient artifacts in the West, some of which we noted earlier. We would try to trace briefly the trends of research, as they developed and the present state of knowledge and see how we can profitably use them. This will have a direct bearing on the approach we have adopted.

BRAIDWOOD *et al* (BN 51) analysed 140 objects from Amouq site (plain of Antioch). They think that gold, bismuth, cobalt, iron, antimony, vanadium and chromium may be useful in tracing the copper ores used by them, though such elements are rather common. They held significant concentrations (0.1 to 10%) of arsenic, nickel and tin to be more reliable in tracing the origin of copper. Their conclusion was that copper-nickel-arsenic alloys are probably natural alloys since both nickel and arsenic are common impurities in copper ores.

[Forbes (below) has contradicted these conclusions.]

THOMSON (Tho 58) pointedly referred to the variability of impurity patterns and the complications in ore-correlations: "In addition to copper, iron and sulphur, pyritic ores often contain not inappreciable quantities of arsenic, antimony, zinc, nickel etc., and of these varying proportions, depending on the exact manner in which the process is carried out, will ultimately find their way into the metal." He further observed that where arsenic and antimony are present, as is normally the case with such ores, special conditions obtain. The oxidation of these elements (to As_2O_3 and Sb_2O_3), results in these volatile compounds being carried away in the fumes from the heap. A part however is converted into the higher oxides (As_2O_5 and Sb_2O_5) which combine with the metallic oxides to form much more stable arsenates and antimonates. The proportion of these elements present in the ore which ultimately enters the metal depends, therefore, on the *exact* conditions under which the roasting is carried out. Emphasising the variabilities he warned, "There is, therefore, no direct correlation between the content of these impurities in the ore, which, it must not be forgotten, may itself vary considerably even over distance of only a few feet, and in the metal; and at any given mine the composition of the roast and hence of the metal produced may have varied from day to day. . . . Such factors as the size of the pieces of ore, the way these are packed, the air supply, the time and the temperature reached, i.e. how well the lumps of ore are broken down, how loosely the heap is packed, and whether the wind is strong may cause daily variations".

[Though his warnings may provide useful caution to the workers in the field, yet his overcautious—rather negative—approach is not justified in view of the important work of Pittioni, Oldberg, Witters and Coghlan.]

FORBES (For 64) says that nearly every copper ore, containing sulphur, antimony, arsenic, lead has upto a few percents of zinc. Nickel is very rare in these ores and hardly ever present in more than traces, as nickel ores are not genetically connected with copper ores; but nickel is introduced into copper as a contamination accompanying iron ores. As iron is slagged away during the smelting, nickel enters the copper. The only nickel bearing ores so far known are confined to America.

There is a genetical connection between nickel, cobalt, iron compounds, but none between copper and nickel ores. Hence the former Sumerian Committee had great difficulty in tracing nickel-bearing copper ores which it believed to be the source of the Sumerian copper objects. These traces of nickel may enter the copper during the smelting process with the flux or from the lining of the furnance. Hence the ratio of nickel and iron is more characteristic of the original ore used than the nickel and copper ratio which the Committee followed up. The difficulty of identifying the original ore lies in the mist still enveloping the ancient operations carried out between the extraction of the ore and the finishing of the tool. Hence more emphasis should be given to extensive metallographical analyses of metal objects. Then we should retrace our steps by investigating various materials used to build furnaces and their mode of working. A most important question is the temperature at which the smelting and melting furnaces worked. More attention should be paid to the composition of slags, which reveal the data on the fluxes used during smelting. We must not attach too much importance to variations in composition which may have been just what might be expected from normal practice in early times where such important points as temperature control were hardly extant.

[Forbes' remarks have a great bearing on the work done on the Indian artifacts and their ore correlations. So far, mere presence of nickel has been used as an evidence for the use of Indian ores.]

COGHLAN reported (Cog 60) a long list of elements which the Ancient Mining and Metallurgy Committee selected for ore correlations (AMM 48, 50, 59):

Gold, silver, arsenic, antimony, tin, lead, bismuth, iron, silicon, aluminium, nickel, cobalt, zirconium, manganese, beryllium, cadmium, tellurium, zinc, phosphorus, selenium, platinum, vanadium, chromium, molybdenum, tungsten, mercury, indium, germanium, rhodium, iridium, palladium, osmium, gallium, tantalum, titanium, magnesium and niobium.

Junghans and Sangmeister's researches (BRi 63) in Germany are directed to a statistical grouping of metals over wide cultural and geographical areas, rather than to a closer evolution in which analyses of the ores must run parallel to that of artifacts, in order to trace the mineral sources with as much precision as possible. Their approach gives speedy results and will be of value to archaeologists in giving an overall picture of cultures, manufacturing centres and trade routes. Coghlan's method (Cog 39, 39-40, 42, 51, 51a, 60, 62), which he admits is slower, aims at complete research right back to the parent ore. Clearly there is room, for both methods of approach to the related problem. Bromehead (Bro 48) also pointed out that absence or near absence of a common impurity may be almost as useful a pointer as the presence of a rare constituent. He quoted the examples of azurite and malachite from Altai district which are always accompanied by cerussite ($PbCO_3$).

Coghlan, basing on his own and Pittioni's researches, contradicts Thomson: "Impurity pattern does not vary except in quantity. The impurities pattern of the mineral will be found to appear in the smelted copper, and, under prehistoric conditions of production, this pattern should still be traceable in the metal, even if the end product has been more or less refined. It is this transmission of the 'impurities pattern' which gives us the key to the problems of linking ore and metal" (Cog 60).

TYLECOTE, who dealt with the prehistoric metallurgy of Britain (Ty 62), says, "Certain elements, such as silver and gold, will be concentrated during smelting and therefore will occur in a greater quantity in the smelted product than in the ore. Using rich ores, the concentration factor is not likely to be much greater than about 2." Arsenic and antimony behave very similarly under smelting conditions and are therefore likely to be present in the smelted copper in the same ratio as in the ore. On this basis he correlates the Kenmare, Kerry ores to the Irish artifacts. In the artifacts the arsenic and antimony ratio is 3 : 1 and in the ores

4 : 1. In the artifacts silver is 0.3% and in these deposits 0.15%, as expected. Zinc, he thinks, will appear in greatly reduced quantities in the artifacts because of its extreme volatility.

A systematic study of both objects and ore deposits in Austria, of the problems connected with early mining, and the treatment and smelting of the ore has been undertaken by PITTIONI (P 57, 59; Bri 63). Research has been concentrated on the regions of early exploitation in Salzburg and Tyrol, where all the major deposits of copper ore have now been examined. Care has been taken to analyse samples from different depths in the deposit so as to define correctly the range of impurities characteristic of the ore-body as a whole. By 1959, they had completed 2000 analyses of ores from ancient smelting places. On this basis, for example, they could correlate the Voralpenland hoard of ingots to Slovakian ores and the Urnfield artifacts to copper deposits of the Bertagrube near Schwaz. As noted before they are basing their conclusions on the transmission of the 'impurities pattern' which gives us the key to the problems of linking ore and metal.

[This method is of great importance to us. A larger number of analyses of the Indian ore-bodies is a desideratum for work on these lines.]

FRIEDMAN *et al's* (FC 66) is the latest work in this series. They analysed ore types and artifacts by optical spectrographic methods of high sensitivity and neutron activation. The latter method was employed for those metallic impurities which were below the limits of spectrographic detection, e.g., native copper.

Since I have used the statistical probabilities derived by them for the analysis of the chemical data, their method is discussed in detail.

"In addition to analysing ore minerals, metallic copper was produced from them by chemical reduction in what was considered to be the simplest, most primitive method possible. Each ore was ground with charcoal and the mixture was heated in a crucible to about 1300° C—the metal formed a button on the bottom. The resulting metal and, in some cases, the slag generated by this process were analysed to obtain a better insight into the behaviour of the metallic impurities and their distribution between slag and and metal. This type of approach revealed which impurities were the best indicators of the original ore type and were most likely to be reliable tracers for relating an artifact to its original source" (FC 66).

A large number of ore and artifact samples from different sites were analysed by them. They divided the ores in three groups:

(i) Naturally occurring metallic copper;

TABLE 15

Relative Probabilities of Impurities in the three types of ore

Unit concentration range	Silver			Arsenic			Iron		
	I	II	III	I	II	III	I	II	III
1	0. 1	0. 62	0. 27	0. 84	0. 62	0. 43	0. 42	0. 35	0. 10
2	0. 05	0. 08	0. 03	0. 05	0. 04	0. 02	0. 26	0. 04	0. 07
3	0. 26	0. 12	0. 13	0. 05	0. 08	0. 03	0. 10	0. 15	0. 03
4	0. 58	0. 04	0. 27	0. 05	0. 19	0. 23	0. 05	0. 08	0. 03
5	<0.005	0. 15	0. 13	0. 05	0. 04	0. 07	0. 05	0. 08	0. 20
6	<0.005	0. 04	0. 17	<0.005	0. 08	0. 13	0. 05	0. 19	0. 13
7	<0.005	<0.005	0. 03	<0.005	<0.005	0. 03	<0.005	0. 04	0. 03
8	<0.005	<0.005	0. 03	<0.005	<0.005	0. 10	<0.005	0. 08	0. 10
9	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0. 08	0. 30

	Bismuth			Lead			Antimony		
	I	II	III	I	II	III	I	II	III
1	1. 00	0. 73	0. 60	1. 00	0. 46	0. 40	1. 00	0. 85	0. 50
2	<0.005	0. 04	0. 03	<0.005	0. 04	0. 03	<0.005	0. 04	0. 03
3	<0.005	0. 19	0. 23	<0.005	0. 12	0. 30	<0.005	0. 04	0. 17
4	<0.005	0. 08	0. 03	<0.005	0. 27	0. 07	<0.005	0. 08	0. 03
5	<0.005	<0.005	0. 03	<0.005	0. 04	0. 13	<0.005	0. 04	0. 17
6	<0.005	<0.005	0. 10	<0.005	0. 04	0. 03	<0.005	<0.005	0. 07
7	<0.005	<0.005	<0.005	<0.005	0. 04	0. 03	<0.005	<0.005	0. 03
8	<0.005	<0.005	<0.005	<0.005	0. 04	0. 03	<0.005	<0.005	0. 07
9	<0.005	<0.005	<0.005	<0.005	0. 08	0. 03	<0.005	<0.005	<0.005

Relative probabilities of the occurrence of impurities in the three types of ores. (I, native copper; II, 'oxidized type' ore; III, 'reduced type' ore).

(ii) Oxidized type include oxides and carbonates like cuprite and malachite and;

(iii) Reduced type include sulfosalts and sulphides e.g. chalcocite, chalcopyrite, tetrahedrite.

"From our studies on the metal produced by reducing many different ores it was found that silver, arsenic, bismuth, iron, antimony and lead were the most important metallic impurities in relating the metal back to the original *type* of ore" (FC 66).

In general they found gold to be very low in concentrations:

Type	*gold conct. in ppm*
'Native' metal	0.0052±.003
'Oxidized'	0.028 ±.007
'Reduced'	0.009 ±.003

Generally tin was less than 0.001%

They worked out the relative probabilities of occurrence of the impurities in the three types of ores : I, 'native'; II, 'oxidized' and; III, 'reduced' (Table 15).

They have used the following logarithmic type of scale for describing the range of impurities:

Unit	*Range of concentration* (%)
1	<0.004
2	0.004 to 0.01
3	0.01 to 0.04
4	0.04 to 0.1
5	0.1 to 0.4
6	0.4 to 1.0
7	1.0 to 4.0
8	4.0 to 10
9	>10

Using the distributions of impurities shown above, the relative probability that a given artifact came from one of the three different types of ores can be calculated.

We will quote the example of a Palestine nail which had the following impurities :

Impurity content. (%)		*Unit Range*
Ag	0.03	3
As	0.5	6
Au	0.001	1
Bi	not detected	1
Fe	0.2	5
Pb	0.03	3
Sb	0.06	4
Sn	5.0	8

For each impurity the corresponding probability of occurrence for each ore type can be found in Table 15. For example, for silver in range 3 the probability is 0.26, 0.12 and 0·13 for the three ore types, respectively. Similarly, for arsenic in range 6, the probabilities are ∠0.005, 0.08, and 0.13. For this particular nail the relative probabilities so found are listed in Table 16.

The relative probability that these concentrations will occur in a given ore type is related to the product of the individual probabilities for each impurity for that ore type. These products are listed in Table 16. Since we are assuming that the nail had to come from one of these three types of ores, the probability should be normalised to 100 percent. Therefore the individual products are divided by the sum of the three products and multiplied by 100. These are listed as the normalised probabilities which are then the relative probabilities that the nail originated from each of the three types of ores.

More than 0.1%tin, they considered as deliberate alloying.

It can safely be assumed for most of the cases, that there was no mixing of ores of different types.

TABLE 16

Probability* of occurrence						Product of Probabilities	Normalized Probability (%)
Ag	As	Fe	Bi	Pb	Sb		
			Native metallic copper				
0.26	<0.005	0.05	1.0	<0.005	< 0.006	<1.95 x 10^{-9}	<0.0082
			'Oxidized type' ore				
0.12	0.08	0.20	0.73	0.12	0.08	5.39 x 10^{-6}	23
			'Reduced type' ore				
0.13	0.13	0.08	0.60	0.30	0.03	1.825 x 10^{-5}	77

*(Relative probability of occurrence, in a nail from Palestine, of copper from each of three types of ore.)

"One other possible error in the technique is that the impurity concentrations could vary with the type of metallurgical process used to produce the copper from the ore. Experiments have shown that 80 to 100 % of the impurities selected here as reliable tracers are transferred from the ore to the metallic copper during the reduction process."

They conclude thus, "The ability to determine the type of ore used to produce a given artifact is one major step in the determination of the location of the ore. When more experiments and analyses would have been completed it may be possible to extend the same statistical treatment to the geographical origin of a given artifact."

I.D. DETERMINATION OF NATIVE COPPER

Before we summarise the various experiences and problems discussed above and spell out the approach adopted by us, it will be pertinent to briefly notice the problems relating to native copper.

There is no unanimity about the origin of native copper, whether it is a primary mineral, or secondary one. It occurs widely in Iran (Talmessi), Turkey (Ergani Mine), Caucasia and Transcaucasia, Cyprus, Hungary and Central Germany, and is most bounteous in North America. Some free metal is found in most copper mines where the deposits have weathered (A 60). Generally native copper is very pure. When trace impurities are present they are not of uniform occurrence in all the native coppers. They may vary from place to place. The following trace impurities are common in the native coppers:

Silicon, aluminium, magnesium, iron, calcium, antimony, arsenic, bismuth, cobalt, lead, manganese, nickel, silver, gold, zinc, tellurium and phosphorus.

Of these silicon, aluminium, magnesium, iron and calcium may be entrapped particles, hence not of much importance. Again iron and calcium are common.

In European native copper a trace of silver is common. In Rhodesian native copper, cobalt is upto 0.1%. In English native copper, tin-silver and lead are common, nickel and bismuth rare. From Slovak Hungarian and Rumanian regions, native copper is generally of a high purity (Cog 62). So far no data are available for the Indian native copper.

Due to geological environment native copper has unusually high hardness (about 108 Brinell hardness).

If not melted, native copper can be distinguished by hardness, usually large grain size and freedom from cuprous oxide. Forbes (For 50) had suggested that it was possible to identify native copper by metallographic study. He referred to peculiar twinned structure of hammered native copper, or the cored structure of such native copper when remelted and cast. Thomson, strongly refuted (Tho 58) such possibilities, "It cannot be too strongly emphasised that neither of these structures is in any way characteristic of native metal." Though he (Tho 58) concedes that native copper, if not remelted, can be identified by the complete absence of oxide inclusions. Coghlan (Cog 60) consoles, "Although for technical reasons one cannot always distinguish native copper from high purity smelted copper, one suspects that the archaeological material is also small in quantity."

Sometimes it is amazingly pure e.g. a Hungarian axe-hammer gave besides copper, the following percentages of impurities (A 60):

Sb	As	Bi	Fe	Pb	Ni	Zn	Ag	Mg	Si	Al
0.0005	0.002	0.0003	0.01	0.008	0.001	0.005	0.003	Tr	0.04	Tr

I. E. SUMMARY AND OUR APPROACH

In every field of science new facts keep on disturbing the initial facile generalisations. So, too, in the field of metallurgical analyses of ancient artifacts. It was thought, in the beginning, that simple analyses can lead to correlation of ores. Such correlation was of great value in determining the origins, contacts, trade and diffusion of metallurgical processes.

Desch started his extensive analysis of ores and artifacts under the aegis of the Sumerian Committee. But his obsession with nickel led him even to Transaval mines for the origins of Sumerian copper, which was simply incredible ! Of course, Oman (Jabal-al-Madan) did have a thin vein which contained 0.19% nickel. We noted the difficulties in identifying Magan with Oman and also in tracing the source of Susa-axes from Arghana ore. Forbes criticising their approach said that the researches of Sumerian Committee did not lead us far. Nickel, not being connected genetically with copper ores, comes from iron ores only as a contamination. Hence Forbes stressed the importance of nickel and iron ratio more than nickel and copper ratio, which the Sumerian Committee had followed.

Most of the Indian workers in the field so far have been following Sanaullah who too attached importance to nickel and arsenic as a characteristic of Indian ores, especially the latter. He believed that they can be distinguished from the Sumerian ores, as they are virtually free of arsenic. We, however, saw that in Khafaje and Ur, 88% artifacts did also contain arsenic (Table 11).

Hegde, however, followed a more modern approach and depended upon the total impurity pattern in spectrographic analyses of ores and artifacts. On the basis of absence of gold and the similarity in the general impurity pattern of Khetri ore and Ahar artifacts he proposed their correlation.

In the light of the modern research in U. K., Austria, Germany and U. S. A., the magnitude of the work that has yet to be done in our country comes in sharp relief. In the present stage both the availability of samples of ores and artifacts—as also the climate for such research—is not very encouraging. But attempts like this one, though humble in scale, would drive home the potentialities of such endeavours to the archaeologists, the minerologists and the chemists. This will lead to experiments and analyses on a scale commensurate with the magnitude of problems for such a vast country as India. In the meanwhile, the results presented here allow us to draw some conclusions—both of tentative and definitive nature—which throw clues towards the solutions of some of the knotty problems of our protohistory.

In determining the types of ores used by different cultures we have done calculations on the basis of Friedman *et al*'s statistical approach. The available data have all been calculated in the manner described above. On this basis we have worked out the relative probabilities for the types of ore used. For this purpose we have depended mainly on silver, arsenic, bismuth, iron, antimony and lead concentrations as being diagnostic for determining the type of ores used.

We will also compare the spectroscopically determined impurity patterns of ores and artifacts to draw probable inferences. Out of the 37 elements recommended by the Ancient Mining and Mineral Committee, we have chosen the following for our work:

Silver, iron, antimony, lead, bismuth, tin, nickel, zinc, manganese, cobalt, gold, aluminium, chromium, molybdenum, zirconium, tungsten, titanium, magnesium, phosphorus and silicon. Though we wanted to do gadolinium and selenium also, no facilities for the same were available to us.

The samples were analysed by emission spectroscopy in the Bhabha Atomic Research Centre. The emission spectroscopy used for qualitative analysis comprises comparison of the wave lengths of the lines in the spectrum of the sample with the spectra of pure elements. To determine the concentration of each element in quantitative analysis—intensity of selected lines for each element has to be measured. This method is fast and requires small samples: even less than 10 mg for doing as many as 20 elements at a time. This method was used both for qalitative and semi-quantitative analyses.

5. II. *Ores and Smelting*

II. A. EARLY MINING

While discussing Sumerian Committee's work above, we had noted the various ores and mines of west Asia (Fig. 11). Elam and Armenia too supplied copper to Asia Minor (Cog 54). When eastern sources got exhausted, search for new mines led to the tapping of European sources.

Wertime (Wer 64) says that Ergani Maaden in Central Anatolia and Anarak-Nachlak, about 80 miles from Sialk, are the two ancient copper mining centres that stand in reasonable propinquity to the copper yielding old sites of this region.

In the early third millennium B. C. there was brisk trade between Dilmun (islands on Persian Gulf) and Ur, a port of Sumer. Copper was supplied in ingots and in the form of manufactured goods too. A lexical list notes three types of copper: 'copper from Dilmun', 'copper from Magan' and, 'copper from Meluhha'. The primary purpose in noting the point of orgin of the copper probably was an indication of its purity and quality (Le 59). It is also possible that Mesopotamia imported copper from Anatolia. Probably it was shipped to Tishmurna and Durhumit as 'black copper' for final refining (Le 59). Assyrian traders who had their agencies in Asia Minor in early second millennium B. C. bought 'bad' (black) and 'good' (refined) copper. The ingots were in the shape of ox-hides. The peaks of production are confined to the periods between *ca.* 2400-2000 B. C. and *ca.* 1500-1200 B. C. The Assyrians also got copper from Urartu (Ararat). Sargon II lists 126 tons of crude copper and hundreds of daggers, lanc heads and vessels amongst the spoils of wars (Cog 54).

Edon near Khirbet-en-Nehas and Umm el' Amad as copper sources for Palestine and Syria dated back to *ca.* 1800 B. C. (For 64).

It is estimated that about 1000 tons of copper were produced in about 1500 years in ancient Egypt. The main source of Egyptian supply was Sinai, though a few eastern desert mines are also known. The presence of crucibles, slags and copper objects prove that the smelting of ore was already practised in Pre-Dynastic times. Production of the oldest mines in the Wadi Magarah (Fig. 11) continued (with a break between Dynasties V and XI) to *ca.* 1750 B. C. From 1600 B. C. onwards mining was concentrated in the region of Serabit el-Khadim, until it ceased about 1200 B. C. by which time Egypt had come to depend upon imports from Cyprus and Armenia (BAAS 33). Remains of miners' habitation and copper working mark these early mining sites. Smelting was carried out at the spot but refining took place in Egypt (GB 27). Sinai mines were most important sources till XXI Dynasty. The Kubban mines may have been used from XII Dynasty and Abu Seyal not before XIX Dynasty (For 64).

Arabah, between Gulf of Aquaba and Dead Sea, too was an early copper mining centre. This was in use from Early Bronze age to the period of Edomites (*ca.* 1100 B. C.).

Cyprus was another important centre. Egypt received supplies from there during Dynasty XIII (*ca.* 1580-1350 B. C.). These mines also supplied Troy, Crete and Greece and were famous in Homeric times.

Early copper mines of Europe were in Austria, Germany, France, Spain, Portugal, Greece, Southern Russia and Tyrol.

In Baluchistan old slag heaps have been found near Shah Ballaul and Robat (Fig. 11). In Afghanistan several copper mines were mentioned by Hiuen Tsang. Safed Kuh mines were exploited as late as Nadir Shah's times (For 64). The districts of Kashan, Kohrud and Isfahan contain many important mines. During the ninth century A. D., the times of Arabian Caliphs, Isfahan, Anarak and Bochara mines were most important sources. The Asshistha valley deposits of the Tiyari mountains are often mentioned in Assyrian and Babylonian records (For 64). We will now note the Indian copper ores and mines below.

II. B. ORES

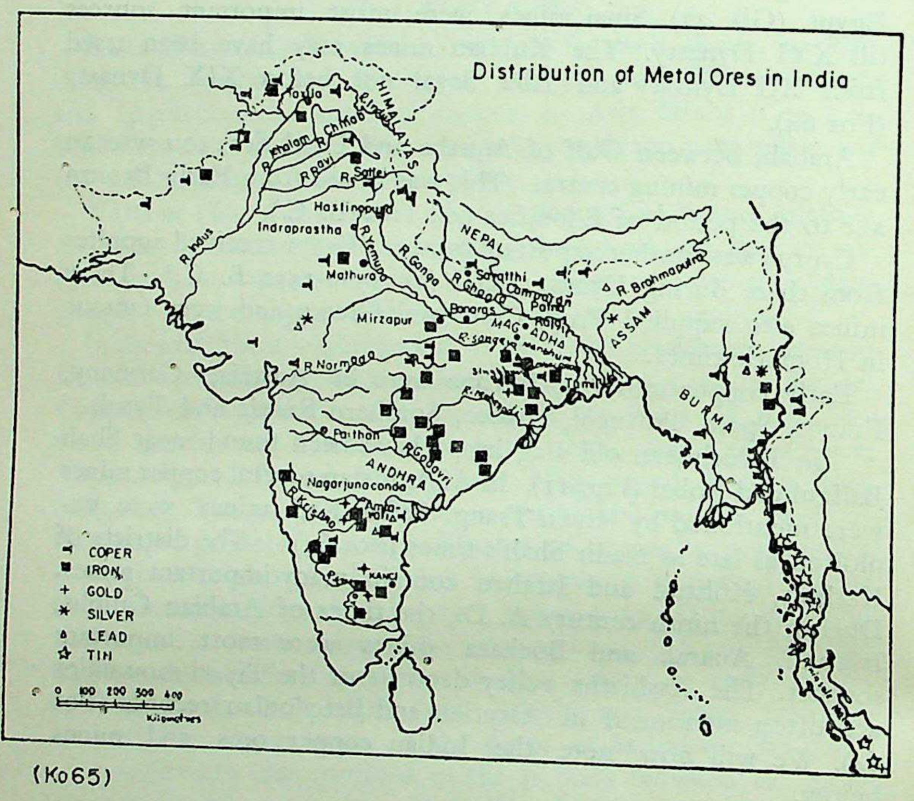
Copper Ores. Copper is very widely distributed in nature. It is found in soil, waters and ores. Native copper occurs on the surface layers of copper and iron ores.

The main Indian copper minerals are (CSR 51; For 64; BC 55):

(i) Chalcopyrite	$Cu_2 S Fe_2 S_3$	34.6 % copper
(ii) Chalcocite	$Cu_2 S$	79.8 % „

(iii) Bornite	$Cu_3 FeSo_4$	55.5 %	copper
(iv) Tetrahedrite	$4 Cu_2 S Sb_2 S_3$	52.1 %	,,
(v) Covellite	CuS	66.5 %	,,
(vi) Malachite	$CuCo_3 Cu (OH)_2$	57.3 %	,,
(vii) Azurite	$2 CuCo_3. Cu(OH)_2$	55.1 %	,,

Present mining areas (Fig. 12) for copper are mainly located in Rajasthan, Bihar, Andhra and Kumaon, though there are several other minor deposits (Dun 65).


Distribution of Metal Ores in India
Taxila
R. Chinab
HIMALAYAS
R. Jhelam
R. Ravi
R. Satlej
Hastinapura
Indraprastha
R. Indus
R. Yamuna
NEPAL
R. Ganga
Savatthi
Champaran
Mathura
R. Ghagra
Patna
Banaras
Rajgir
MAGADHA
R. Brahmaputra
ASSAM
Mirzapur
R. Narmada
Tamluk
R. Mahanadi
BURMA
Paithan
R. Godavri
ANDHRA
Nagarjunaconda
R. Krishna
Amaravati
KANCI
COPER
IRON
GOLD
SILVER
LEAD
TIN
0 100 200 300 400
Kilometres

(Ko65)

Fig. 12. Map showing the distribution of copper, iron, gold, silver, lead and tin deposits in India.

The Singbhum belt extends over a region 130 km. long and upto 8 km wide. In 1959 the reserves of copper ore were estimated to be 3.8 million tonnes with an average 2.47% copper content. New explorations have brought to light copper ore resources of Patharghora, Surdha, Kendadih, Roam-Sidheshar area. In Andhra, Guntur, South Arcot and Hassan districts too have yielded copper ore deposits. Guntur belt is 4.8 km long. Ore deposits of Jabalpur area are very poor. The veins of copper minerals are only 6″ to 3′ in width. The minerals are chalcopyrite and tetrahedrite. These ores are in dolomite limestone regions (Hegde, therefore, expected calcium to be present in the Chalcolithic artifacts, in case these ores were used.) In Rajasthan, copper ore mines are located in practically all the divisions. The most important of them are at Khetri-Singhana in Jhunjhuna district (Seh 56). This belt continues from Singhana to Raghunathpura, about 80 km. In this belt, in the Mardan-Kudan section there is a reserve of 28 million tonnes of ore with 0.8% copper and in the Daribo area 0.5 million tonnes ore deposit of 2.5% copper. The mineral found in these places is chalcopyrite ($CuFeS_2$) which is usually disseminated in schists and phyllites.

Below we will note some of the main occurrences and details of copper ores in Rajasthan, as this area has a greater importance for the protohistoric sources. The details are based on Sethi (Seh 56), Dunn (Dun 65), (IAR 61-62), Mujumdar and Rajguru (MR 62-63), and Srinivasan (Sri pc).

(i) *Khetri Singhana* (Jaipur Dist.)

Outside Singhana several million tonnes of slag heaps are lying. The ore used chalcopyrite (old name, 'Dha'), which occurs with pyrrhotite disseminated in shales, phyllites, schists and quartzites. At places copper content of ore is 0.75 to 4%.

(ii) *Kho-Dariba* (Alwar Dist.)

Ore occurs as veins and lodes in most phyllites along the contact plane separating them from quartzites. The mineralisation of chalcopyrites and chalcocites occur here under gossan area. Incrustations of chalcanthite were also seen. Old slag heaps are reported.

(iii) *Delwara Kirovli* (Udaipur Dist.)

Old workings are reported from Delwara, Kotri, Vilota, and Kirovli. Extensive slag heaps were found at Delwara and Kirovli (IAR 61-62). Chalcopyrite and Malachite is associated with quartzites and biotite-actinolite schists. Malachite has 6.8% copper.

(iv) *Debari* (Udaipur Dist.)

Ores are malachite, chalcopyrite, cuprite, azurite and bornite.

Rajguru and Mujumdar (IAR 61-62) reported many such sites from this area. Some of the openings, e.g. Kotri and Delwara, appear to be very crude and small in dimensions, the deepest amongst these being 36.5 m.

The controlling factor in localising the ores is, in most cases, a fault or a shear zone. The old rock formations met with in this area are pre-Aravalli gneisses, quartzites, and dolerites of the Aravalli series and dolematized limestones, porcellainites and epidiorites of the Raialo series. Most of the old workings are situated in harder geological formations such as quartzites.

The slag pieces studied by them (MR 62-63) showed great variation in size, shape, composition, density etc. From froth-like glassy to heavy iron-rich varieties were reported. Portions of clay retorts, crucibles and other pots, as also malachite stained quartz pieces were collected from these heaps. They grouped the slag pieces in the following way:

(i) heavy and massive type containing more iron and possibly copper and other silicates;
(ii) lighter types with lesser iron and more of silica and other silicates;
(iii) glassy froth and;
(iv) slag pieces fused with clay and fine sand.

Similar glassy froth found at Ahar (Table 22) from purely Chalcolithic horizons was analysed by Hegde (He the).

Srinivasan (Sri pc) has traced the history of Khetri belt workings upto Mauryan times. Abul Fazl (A. D. 1590) mentions these mines and in recent times Captain Baileau (A. D. 1830) reported it first.

Sanahullah (San 31) gave the following probable sources (Fig. 11, 12) of copper ores for the Indus copper:

Baluchistan : Shah Ballaul, Robat, Raskuh and Kojak Amran
Afghanistan : Shah Maksud and Kalih Zeri
Persia : Anarak
India : Ajmer, Sirohi, Mewar, and Jaipur.

Pascoe (in Mar 31) also has noted other sites like Safed-Kuh, Nesh, Tezin, Musai, Silwatu pass in Afghanistan and Karadigh and Kirman hills in Persia. On the basis of nearness, he thought that Jaipur state, Shah Maksud and Robat were more likely sources for the Indus copper. From India, Forbes (For 64) mentions old workings from Shan States, Indore, Nellore, Kistna Dist., Rupawati in Kathiawar, Ambar Mata and Kumbaria in North Gujrat and Nepal, though he is doubtful that they were worked before the Hellenistic times. The ancient copper mines of Bamian near Kabul and in Kafiristan and the Paraponisus form the eastern extension of the copper belt which runs through northern Persia upto Caspian Sea and beyond the Transcaucasia. There are mines of Kal-Sabzarre, Sabzawar and Fahr Daud near Meshed, Kaleh near Astrabad and in Elburz mounts. The districts of Kashan, Kohund and Isfahan contain many important mines. There are easily reducible carbonates in Binamar and Pankaleh. The Ashistha valley deposits of the Tiyari mountains are often mentioned in Assyrian and Babylonian records. Mallowan (Mal 65) identified Magan (a copper supply centre) with Zagros mounts and mines of Persia. For the supply of Indus copper, Mackay (M 43) thought Persia as more likely because both tin and copper ores occur plentifully in that country. An oxide ore from Mohenjodaro excavations was analysed by Desch (BAAS 35).

As arsenic and tin both were used for alloying, to improve the moulding characteristics of copper, we will note their occurrences too below.

Tin Ores

Main tin ore is cassiterite, which when pure, contains 78.6% tin. But vein ore is so mixed up with quartz that only 0.2 to 2.0% tin is found in it. In these veins cassiterite is found as dark brown or black bands. Generally such stanniferrous veins are found in granitic rocks which on disintegration give away their cassiterite in the river streams along with alluvial gravels and it is called stream tin. Though the vein ore is poor in tin, washing action of the stream concentrates it. Stannine (containing 25% tin) is rare in the Occident and the complicated technology required to use it rules out its use in antiquity. The main tin fields (Fig. 13) of antiquity are the following:

Asia Minor. Darmanlar, Murad Bagh and Kastamuni.

Caucasus and Transcaucasia. Belaia river basin, region between Elburz and Terek, Gori region, Sharopani, Karadagh and Karadagh mounts.

Persia. Kuh-i-Sehend near Tabriz, near Astrabad and Damghan, Kuh-i-Benan.

Asia. Near lake Baikal, tin belt extending from Burma, Malaya to Billiton.

Indian Tin Ores

There is no production of primary tin even now in the country, though our requirements are 4,500 tonnes per year. Tin ore deposits are known from Hazaribagh, Ranchi, Gaya in Bihar, Banas Kantha in Gujarat, Dharwar in Mysore and Bhilwara in

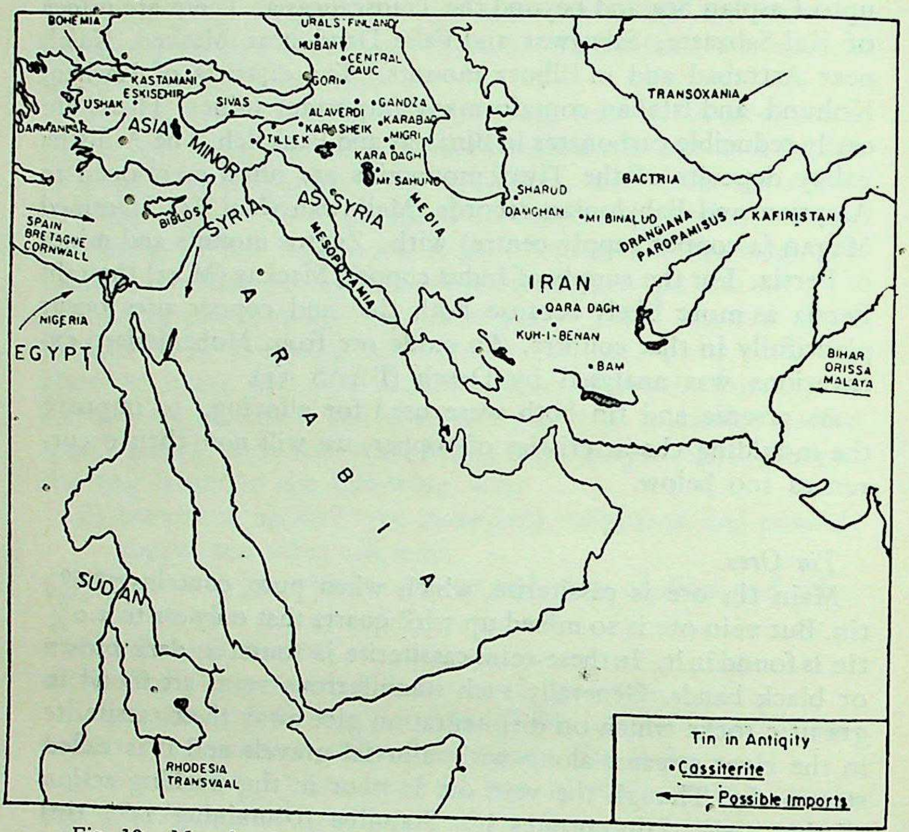

BOHEMIA
URALS FINLAND
KUBAN
CENTRAL CAUC
GORI
KASTAMANI
ESKISEHIR
USHAK
SIVAS
ALAVERDI
GANDZA
KARABAG
KARASHEIK
MIGRI
TILLEK
KARA DAGH
MT SAHUND
DARDANELS
ASIA MINOR
TRANSOXANIA
BACTRIA
SHARUD
DAMGHAN
MT BINALUD
DRANGIANA
PAROPAMISUS
KAFIRISTAN
SPAIN
BRETAGNE
CORNWALL
BIBLOS
SYRIA
ASSYRIA
MEDIA
MESOPOTAMIA
IRAN
QARA DAGH
KUH-I-BENAN
BAM
NIGERIA
EGYPT
ARABIA
BIHAR
ORISSA
MALAYA
SUDAN
RHODESIA
TRANSVAAL
Tin in Antiqity
• Cassiterite
← Possible Imports

Fig. 13. Map showing distribution of tin ores (Cassiterite) in West Asia.

Rajasthan (PD 64). But nowhere are they economically exploitable. There are no indications of old mining as it is more likely that the stream tin was used for alloying (San 31, 40). It is also likely that the Indus people got their tin from Khorasan and Karadagh mines (Fig. 13).

Arsenic Ores

Realger and orpiment—the ores of arsenic—are imported today. Arsenic minerals have been reported from West Bengal, Rajasthan, Kashmir and Bihar (PD 64), though they are not economical.

Arsenic is in quite high proportions in Indus artifacts (Tables 17, 18 and 19). When arsenic is less than 1% it cannot be decided whether it was from copper ores or from ores like lollingite ($Fe As_2$) which have been reported from Nal (Table 20). But more than 1% arsenic was a deliberate addition.

TABLE 17

Percentage Composition

Site : Mohenjodaro from Lower Levels

Based on (M 37-38)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	S	REL. I	PROB. II	% III
1. Pl.CXXVI, 5 DK 7535	—	0.33	0.66	0.25	0.59	—	91.01	6.14	0.48	0.12	0	18	82
2. Pl.CXXVII, 2 DK 7854 Axe	—	0.50	—	0.43	0.95	—	90.98	7.66	0.20	0.07	0	40	60
3. Pl. CXXVI, 2 DK 7856 Chisel	—	0.51	—	1.25	0.39	—	75.25	7.84	0.61	—	0	23	77
4. Portion of Axe. DK 7861	—	0.10	—	0.14	0.22	—	88.49	9.88	0.30	0.06	0	44	56
5. Pl. CXXVIII, 1 DK 5486 Axe	—	0.34	2.10	Tr	0.20	—	80.56	1.76	0.58	—	1	54	45
6. PL. CXXXIII,4 DK 6043 Chisel	—	0.02	1.58	0.54	Tr	—	86.92	8.56	0.68	0.07	5	15	80
7. Pl. CXXVIII, 15 DK 5360 Copper Frying Pan	—	0.33	0.80	0.18	0.05	—	81.94	0.37	0.21	0.14	0	38	62
8. Pl. CXXVII, 14 DK 7343 Bolt	—	0.29	0.24	—	0.81	—	97.23	—	0.89	0.10	0.	69	31
9. Pl. CXXVI, 4 DK 7853 Axe	—	0.28	0.40	0.06	0.71	—	94.64	0.31	0.33	0.69	0	6	94
10. Pl. CXXXI, 32 DK 7859 Ingot (?)	—	0.56	0.24	—	0.82	—	95.23	—	0.41	0.48	1	83	16

TABLE 18

Percentage Composition

Site : Mohenjodaro

Based on (PR '65)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	REL. PROB.% I	II	III
Bronze chisel	—	0.35	—	0.35	0.70	—	86.22	12.38	—	0	34	66
Copper lump	—	0. 5	—	—	—	—	96. 8	—	0.3	16	77	7
Bronze button	—	0. 3	—	—	—	—	89. 1	10.6	—	26	36	18
Bronze rod	—	0.41	—	—	22.83	—	69.76	6.65	0.33	—	—	—
Lump	—	0.41	—	—	—	—	99.93	0.26	—	16	77	7
Piece	—	1.24	Tr	0.77	—	—	97.79	0.07	0.13	2	30	68
Alloy piece	—	1.51	0.81	—	32.17	—	65.27	0.01	0.23	—	—	—
Piece	—	1.29	Tr	0.33	Tr	—	98. 2	Tr	0.18	6	56	38
Fulcrum bar	—	—	2.23	—	0.10	—	96.16	0.88	—	2	45	53
Piece	—	0.09	—	—	—	—	99.63	—	0.28	31	66	3
Lump	—	—	4.38	—	0.90	—	93.56	0.79	0.41	2	52	46
Celt	—	0.36	0.48	—	1.03	—	95.45	2.47	0.21	1	60	39
Frying Pan	—	0.39	0.95	0.22	0.06	—	97.53	0.44	0.25	0	38	62
Crow bar	—	0.29	0.24	—	0.81	—	97.66	—	0. 9	2	58	40
Celt	—	0.29	0.40	0.06	0.73	—	97.15	0.32	0.34	0	69	31
Lump	—	0.58	0.25	—	0.84	—	97.43	—	0.41	1	83	16
Celt	—	0.33	0.67	0.25	0.59	—	91.40	6.16	0.48	0	18	82
Chisel	—	0.59	—	1.45	0.45	—	87.66	9.14	0.71	1	56	43
Lump	—	0.10	—	0.14	0.22	—	89.21	9.97	0. 3	0	10	90
Celt	—	0.39	2.45	Tr	0.23	—	94.17	2.06	0.68	0	9	91
Bar	—	—	1.60	0.55	Tr	—	88.39	8.70	0.69	6	11	83

TABLE 20

Percentage Composition

INDIAN ORES

Key: ns = not seen
nd = not detected

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	Mn	Co	S	Al	Mg	Mo	Ti	V	Au	Cr	Gd
1. Chalcopyrite* Singbhum TF-Cu-15	nd	>1.0	nd	nd	nd	nd	>1.0	nd	0.1 to 1	.001 to 0.1	.001 to 0.1	.001 to 0.1	— —	0.1 to 1.0	0.1 to 1.0	.001 to 0.1	.001 to .1	.001 to .1	nd	ns	nd
2. Pyrrhotite* Ore-Madras TF-Cu-14	nd	>.1	nd	nd	nd	nd	<0.1	nd	>.1	<0.1	nd	>.1	>.1	nd	nd	nd	nd	nd	ns	nd	ns
3. Chalcopyrite* Khetri TF-Cu-24	<.001	>1.0	<.05	<.0025	<.0025	<.0025	>1.0	<.0025	0.2	<.0025	0.1	0.1	—	1.0	0.5	0.5	<.005	0.1	—	<.001	>1.0
4. Chalcopyrite Khetri	nd	26.93	4.28	—	3.81	0.23	4.82	nd	1.97	1.36	2.18	—	—	—	—	—	—	—	—	—	—
5. Copper Ore Mohenjodaro	—	—	0.37	—	Tr	—	76.15	—	0.23	—	—	—	1.12	—	—	—	—	—	—	—	—
6. Lollingite Nal	—	49.3	43.6	—	—	—	0.7	—	—	—	—	—	0.16	—	—	—	—	—	—	—	—

[Nos. 1 to 3, my samples; 4 based on (He the); 5 on (BAAS 35); 6 on (Ha 29).]
* Semiquantitative spectroscopic analysis.

TABLE 19

Percentage Composition

Site : Harappa

Based on (PR 65)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	REL. I	PROB. II	% III
Celt	—	0.41	—	Tr	Tr	—	91.52	7.85	0.22	—	16	78	6
Lance head	—	0.13	—	Tr	—	—	97.87	—	0.40	—	27	55	18
Rod	—	0.98	0.70	0.19	—	—	97.20	0.84	0.09	—	0	40	60
Dagger Point	—	0.74	0.04	0.44	0.88	—	91.00	6.76	0.14	—	0	92	8
Dagger	—	0.40	6.69	—	2.85	—	89.88	—	0.18	—	0	61	39
Fragment	—	0.41	0.66	—	Tr	—	98. 6	0.07	0.26	—	4	80	16
Celt	—	0.02	1.41	—	0.11	—	98.36	—	0.10	—	1	82	17
Chisel	—	0.09	0.36	0.31	Tr	—	92.61	6.43	0.20	—	2	52	46
Celt	—	0.41	Tr	—	0.20	—	91.32	7.85	0.22	—	1	75	24
Helmet sheet metal	—	0.07	1.19	Tr	0.85	—	97.69	0.15	0.05	—	1	73	26
Chisel	—	0.34	1.10	—	0.52	—	87.42	10.45	0.17	—	1	29	70
Needle	—	1.37	0.40	0.42	0.10	—	88.79	8.75	0.17	—	0	56	44
Spearhead	—	1.11	0.06	—	0.70	—	97.66	0.33	0.14	—	0	88	13
Celt	—	1.11	0.06	—	0.70	—	88.37	—	0.14	—	0	88	13
Needle or awl	—	1.37	0.42	0.42	0.10	—	88.35	9.16	0.18	—	0	1	99
Saw	—	0.41	0.65	—	0.10	—	98.12	0.33	0.39	—	0	57	43
Chisel	—	0.39	0.60	—	0.20	—	94.92	3.60	0.29	—	0	26	73
Lance head	—	0.13	0.68	—	Tr	—	98.69	0.10	0.40	—	1	57	42
Needle	—	0.20	2.96	—	3.72	—	92.55	0.29	0.21	0·07	0	30	70
Dagger	—	0.47	0.26	—	0.98	—	91.87	6.42	Tr	—	1	98	1

TABLE 21

Percentage Composition

Sites: Jorwe, Chandoli, Nevasa, Navdatoli, Somnath and Ahar

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	Mn	Co	S	REL. PROB.% I	II	III	Reference
1. Jorwe Copper Axe	—	—	—	—	—	—	98.40	1.78	—	—	—	—	—	47	51	2	(SD 55)
2. Jorwe Copper Bangle	—	—	—	—	—	—	99.0	—	—	—	—	—	—	,,	,,	,,	,,
3. Chandoli Spearhead CDL 105 Layer 5, Tr-1	—	1.23	Tr	—	1.55	Tr	96.39	—	0.31	0.41	—	Tr	Tr	0	92	8	(He the)
4. Chandoli Axe from CDL 30 Layer 7, Tr-2	—	1.81	Tr	—	1.68	Tr	95.11	—	0.26	0.62	—	Tr	Tr	0	92	8	,,
5. Nevasa Chisel No. 6721	—	0.10	—	—	0.61	—	94.41	2.72	0. 2	0.13	0.17	—	—	2	77	21	(SDA 60)
6. Nevasa Bangle No. 6722	—	—	—	—	—	—	98.31	—	—	—	—	—	—	47	51	2	,,

Contd.

TABLE 21 (contd.)

Percentage Composition

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	Mn	Co	S	I	II	III	Reference
7. Nevasa Copper Bead No. 6723	—	—	—	—	—	—	99.06	—	—	—	—	—	—	47	51	2	(SDA 60)
8. Navdatoli Bangle NVT 1385 Layer 1, Tr-I	—	0.72	—	—	2.28	—	91.56	4.37	0.37	0.28	—	Tr	—	1	92	7	(He the)
9. Navdatoli Axe	—	0.63	—	—	2.28	—	93.17	3.26	—	0.21	—	—	—	1	92	7	,,
10. Navdatoli Chisel	—	0.57	—	—	2.06	—	93.20	3.12	—	0.38	—	—	—	1	92	7	,,
11. Axe from Somnath	—	2.57	Tr	—	1.21	Tr	81.86	12.82	—	—	—	Tr	—	0	92	8	,,
12. Ahar Metal Sheet A.2326 Layer 13, Tr.A.	—	1.22	Tr	—	1.64	Tr	96.28	—	0.26	Tr	0.31	Tr	Tr	0	92	8	,,
13. Axe from Ahar	—	6.48	—	—	1.62	—	90.92	—	0.31	—	—	—	—	0	88	12	,,

Lead Ores

Lead mines of Zawar, Rajasthan, are said to have been worked from the times of Rana Lakha Singh (A. D. 1382-97). Only Zawar deposits are economically exploitable, though ores are reported from Kurnool, Agnigundala (Guntur), Baraula (Kashmir), Almora, etc.

Lead was added to increase the fusibility of copper for better moulding. It has been reported extensively in Harappan artifacts (Tables 17, 18, 19), also from the other Chalcolithic sites (Table 21).

Several lead objects and lead ores are reported from Harappan sites. The lead ore from Mohenjodaro examined by us showed only antimony and lead (Table 32, TF-Cu-5).

II. C. SMELTING

The various stages (For 64) through which copper metallurgy passed are given below:

Stage I Shaping native copper by:
hammering, cutting, bending, grinding, polishing.

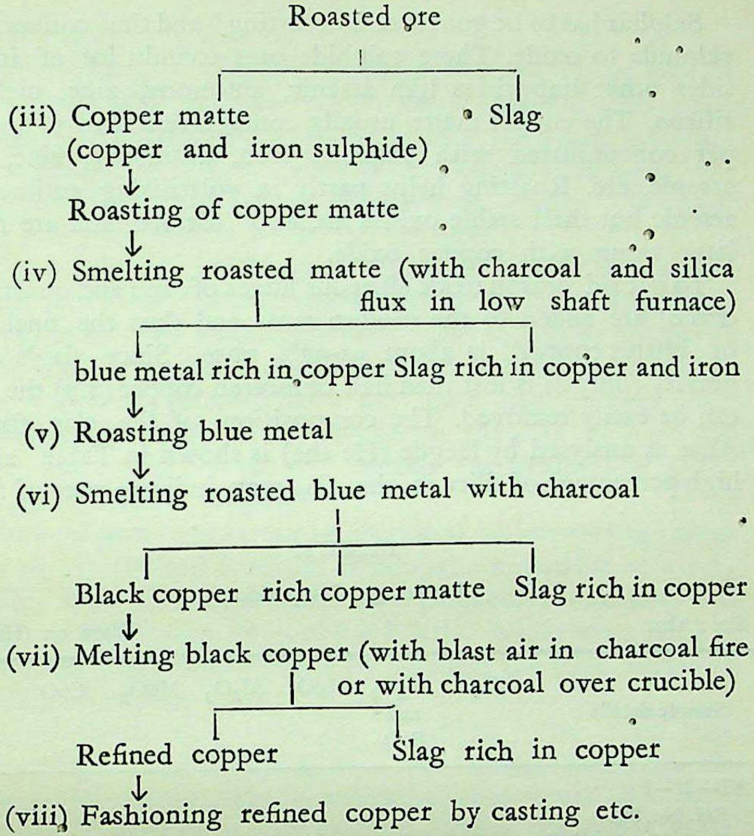
Stage II Annealing native copper by:
heating and hammering.

Stage III Smelting oxide and carbonate ores:
Smelting ore in wood or charcoal fire over a clay lined pit with air.

regulus slag (thrown away)

Stage IV Melting and casting copper.
Melting native copper or regulus over furnace or fire in a crucible and casting into stone, clay or sand moulds. Fashioning by cold work, annealing, finishing by grinding and polishing.

Stage V Smelting sulphide ores
(i) Roasting the ore to remove bulk of sulphur.
(ii) Smelting roasted ore (with charcoal in low shaft furnace)


Roasted ore
(iii) Copper matte
(copper and iron sulphide)
Slag
Roasting of copper matte
(iv) Smelting roasted matte (with charcoal and silica flux in low shaft furnace)
blue metal rich in copper
Slag rich in copper and iron
(v) Roasting blue metal
(vi) Smelting roasted blue metal with charcoal
Black copper
rich copper matte
Slag rich in copper
(vii) Melting black copper (with blast air in charcoal fire or with charcoal over crucible)
Refined copper
Slag rich in copper
(viii) Fashioning refined copper by casting etc.

The end product, tough pitch copper, of 99.5% purity was obtained during final smelting with charcoal and blast air. Blast air however leaves cuprous oxide which makes the copper brittle. To avoid this, green hard wood is thrust into the molten metal which at once catches fire and gives out hydrocarbon gases which reduce the copper oxide. This operation is called "poling". Correct poling was very essential and it was clearly controlled before 2000 B. C. (For 64). So many cuprous oxide inclusions in our Chalcolithic artifacts (Chapter 6) may indicate the absence of proper poling.

With the use of sulphide ores minor impurities in the artifacts increased (A 60; FC 66; For 64). Problems of ore-correlations and types of ores used in India will be dealt with later.

In describing Stage V we noted the various processes involved in smelting and refining the sulphide ore. It is obvious that simple oxide and carbonate ores would be directly reducible with charcoal at dull red heat but the copper obtained would form a spongy mass difficult to deal with (M. P. of copper 1083°C).

Sulphur has to be got rid of by roasting* and thus converting the sulphide to oxide. These sulphide ores contain lot of iron, besides other impurities like arsenic, antimony, zinc, nickel and silicon. The copper matte usually contains less than 50% of copper contaminated with sulphur, iron, antimony, zinc, silver, arsenic, etc. Roasting helps partly in volatilising antimony and arsenic but their stable oxides are also formed and are reduced later along with copper oxide.

To get rid of iron oxide siliceous fluxes of sand and quartz (powdered) are added to the molten mass and thus the final "black or blister copper" is about 95-97% pure. Since slag's specific gravity (only 4) is less than half of molten copper (8.7) the slag** can be easily removed. The composition of the slag found in Ahar as analysed by Hegde (He the) is shown in Table 22. The high percentage of silica in the slag may indicate use of fluxing.

TABLE 22

Percentage Composition

Site : Ahar

Based on (He the)

Sample details	SiO_2	Fe_2O_3 and FeO	MgO	Al_2O_3	MnO_2	CuO	SO_3
AT—27—I Ref. No. 921 Tr. J, Depth 29′ 6″ Chalcolithic Pd Phase—B Slag.	38.16	45.32	3.02	5.96	1.89	0.91	4.14
AT—27—II Ref. No. 1035 Tr.D, Depth 24′ Chalcolithic Pd Phase—C Slag	35.18	48.26	2.39	5.25	1.16	0.67	6.08
AT—27—III Ref. No. 1487 Tr. J. Depth 31′ Chalcolithic Pd. Slag	37.12	43.89	3.61	7.79	2.15	0.86	3.63

** $2Cu_2S+3O_2=2Cu_2O+2SO_2$.
$2Cu_2O+FeS=Cu_2S+FeO$.
$FeO+SiO_2=FeSiO_3$ slag.

*$CuFeS_2+O_2=Cu_2S+2FeS+So_2$.

5. III *Alloying*

Copper is alloyed to improve its casting properties, as also its hardness and tensile strength. Metals when heated absorb gases. Pure copper has a tendency to 'gas' when cast, producing a porous casting. Addition of tin or arsenic considerably reduces this tendency as they function as deoxidising agents. Without alloying, complex casting is out of question.

"An Irish halberd containing 2.61% arsenic, 0.91% antimony and 0.2% silver had Brinell hardness of 79 in the cast portion, and of 132 in the cold worked portion. This should be compared with hardness of 120-160 of cast tin-bronze, and 40 of pure copper (Ty 62). However arsenic does not have that marked effect on increasing the strength of copper in the cast or annealed conditon; but 1.04% arsenic will increase the hardness from 124 to 177 in hammered copper.

Hardness of pure copper can be increased by hammering alone from 87 to 135 (Brinell hardness numbers) comparable to a 10% tin-bronze. But to retain a sharp edge frequent hammering will be needed, which makes the tool too brittle. While work hardening would make the bronze much harder than the pure metal in comparable condition.

In copper-arsenic alloy, upto 4% of arsenic forms solid solution (Chapter 6). In solidifying from the molten state, first the portions of each crystal grain crystallise—that is to say, the nucleii of the primary branches or crystallites—which are richer in the metal with higher melting point (here copper) than the succeeding layers, and this gradual process goes on until the liquid metal of each portion solidifying last of all is rich in the metal with the lower melting point (here arsenic) (GB 27).

Tin is soluble in copper upto 16% only in the solid state; if tin is in excess of that, a second constituent remains even after prolonged annealing. As a result of ordinary casting, bronzes with more than 8% tin show the presence of the second constituent. Between 8-16% it is only as a result of annealing that homogenous solid solutions can be obtained (GB 27).

Solid solutions (in contrast to eutectics) have a greater hardness than any of the individual elements they are composed of, and yet have sufficient ductility to enable them to be worked both hot and cold. When cold worked the hardness of such solid solutions is increased still further.

About the definition of alloy in ancient world there is considerable difference of opinion. Coghlan (Cog 54) includes only alloys with 5-15% tin as bronzes, below this limit he calls them accidental bronzes. Tylecote (Ty 62) however includes all alloys containing more than 1% tin in the category of bronzes. Thomson, despite Gowland's and Burton Brown's (Bu 51) claims to the contrary, does not believe that the copper with less than 1% of tin or arsenic could be deliberate alloys. It could only be due to the use of impure ores.

It will now be relevant to trace the origins of bronze in west Asia and Europe and see when it first appeared in the north-west frontier of India.

In Europe

In U. S. S. R. the III-II millennium B. C. archaeological monuments of Caucasus region are included by archaeologists in Eneolithic (Mon 61). But Selimkhanov (Se 62), on the basis of extensive spectrographic analyses, says that amongst them there is not a single one made of pure copper. The maximum content of arsenic is 10%, the other impurities are minor. Therefore he prefers to include them in the Bronze Age, rather than in Eneolithic. So also from some sites in Azerbaijan, tin alloying upto 10% is observable. "Such copper-arsenic alloys may be easily got by means of a combined fusion of copper and arsenic materials, and rich occurrence of the latter exist in the territory of the Caucasus" (Se 62).

In India too the Chalcolithic cultures have been termed neolithic (Chapter 4). But the knowledge of smelting and alloying entitles their inclusion in the Bronze Age.

Tylecote (Ty 62) has worked out groups of copper for England. From the histogram it is obvious that less than 1% arsenic is an impurity and they may be termed pure coppers. Average 2% arsenic-containing-coppers are deliberate arsenic alloys.

In Asia

The sporadic appearance of high tin content (10%) bronzes in the deposits of Troy I, Thermi I, Alishar I and Tepe Gawra VIII, all of which date from before ca. 2500 B. C., suggests that already at that remote date such experiments were being tried at least in some areas (Bu 51). The high content of arsenic in Geoy Tepe K Pd may also be due to deliberate alloying. Towards the end of K Pd at Geoy Tepe (*ca.* 2500 B. C.) arsenic appears more frequently and in higher proportions in the Near East, than ever before. Perhaps the idea of deliberate addition of arsenic to copper to harden and cast it properly came with the arrival of G people in Geoy Tepe. Thomson criticised Voce for be-

TABLE 23

Early Bronze Percentage Composition

Based on (Tho 58)

	Copper	Tin	Iron	Nickel	Sulphur	Lead	Arsenic	Zinc	Bismuth	Antimony	Silver
Special 'Bronzes'											
A. Later Third Millennium (Arsenic)	95.0	Tr.	0.3	0.1	—	0.3	4.2	—	Tr.	—	—
B. Later Third Millennium (Lead)	85.8	3.5	0.2	—	—	8.5	—	—	—	—	—
C. Later Third Millennium (Iron)	93.	—	5. 9	—	1.0	—	0.1	—	—	—	—
D. (Arsenic) (Refined Copper ?)	(92.8)	n.d.	<0.01	0.1	—	0.01	~7	n.d.	0.02	0.05	0.02
Tin Bronze											
VI. Later Third Millennium (Impure Copper)	(93.84)	5. 0	0. 5	0.05	—	0.2	0.2	—	0.002	0.2	0.005
VII. ,,	(86.93)	10.62	0.25	0.49	—	0.68	0.77	—	—	0.32	–
VIII. Second Millennium (Refined Copper)	(89.47)	10.0	0.1	0.3	—	0.03	0.05	—	0.0005	0.03	0.01
IX. Composition of Copper calculated from VIII	(99.4)	—	0.11	0.33	—	0.033	0.055	—	0.0005	0.033	0.011

(Tr.= trace; n.d. = not detected spectrographically. Figures for copper in brackets are by difference) lieving that even 0.5% tin was a deliberate addition in Geoy Tepe D.

The Royal Cemetery (Ur) bronzes have 0.5 to 14.5% tin. Burton (Bu 51) says that in the II millennium B. C. except for Egypt and Geoy, arsenic is very rare in bronzes of this period. At Thermi arsenic is completely absent from both coppers and bronzes and contrasts strongly with the previous greater frequency.

Thomson (Tho 58) has also discussed the percentage compositions of coppers of different periods (Table 10 and 23). "It is my belief that it was due to the ores of this kind that the group of impure coppers, illustrated by analyses IV and V in Table 10 (my no. —D. P. A.) originated. . . . it is inconceivable to me that such a complex alloy would, or could, be produced deliberately by the metallurgist of the times which we are considering" (Tho 58). Early bronzes had all kinds of contaminations which later bronze did not have, as they were made from pure 'poled' copper and tin ore. On the other hand (Table 23, VIII, IX) compositions were the result of definite intent. The replacement of arsenic and antimony by tin can hardly be explained except on the assumption of definite experimentation.

In the Late Uruk times the copper smiths had learned to alloy copper with lead to lower the melting point and could cast *cire perdue*, but there is no evidence for tin bronze. Tin bronze appears in Early Dynastic times at the latest (Ch 57). During this period tin percentage varies from 1-11% in bronze (Table 8).

Aitchison (A 60) has noted that samples from pre-diluvial Ur (Table 8), Al' Ubaid and Kish (Table 6) are of pure copper without tin alloying. But many specimens from Ur graves (Table 6) and of I Dynasty of Ur contain tin as also nickel (tin upto 8-11%). This alloying of course was deliberate, but still a large number of artifacts were made of pure copper. But during Sargonid period, tin is only an impurity. Both at Kish and Ur now, instead of the previous 10% tin, we have only 1% or less. It appears that the supplies of West Asiatic tin ores exhausted well before the close of the III millennium B. C. About the end of III millennium B. C. again there is a revival of bronze making, as tin ores of Bohemia and Saxony were opened up (A 60).

For mirror making, Romans had found out that the highest reflective power could be achieved by using 23-28 % tin and 5-7% lead. It will be interesting to analyse Indus and Kulli mirrors too, as both tin and lead were known.

Reporting on the Amouq (Syria) bronzes, Braidwood *et al*

TABLE 24

Percentage Composition

Site : Mundigak

Based on (Cas 61)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	SiO_2	O_2
9.041.053 1. M.G.A. C. Pd.III,6	—	0. 1	—	—	—	—	75.44	0. 6	—	—	2.44	20.44
9.041.054 2. M.G.A. LIII Pd.IV, 1	—	0.09	—	—	1.54	—	89.85	1. 4	—	—	1.91	5.19
9.041.055 3. M.G.A. CCCXIX Pd.I, 5.	—	0.12	—	—	—	—	80.23	0.86	—	—	3.96	14.81
9.041.053 4. M.G.A. C. Pd.III, 6	—	0.13	—	—	—	—	99.10	0.77	—	—	—	—
9.041.054 5. M.G.A. LIII Pd. IV, 1	—	—	0.1	—	1.66	—	96.74	1. 5	—	—	—	—
9.041.055 6. M.G.A. CCCXIX Pd. I, 5	—	0.15	—	—	—	—	98.79	1.06	—	—	—	—

(Samples 1, 2 and 3 were badly oxidised. Analyses 4-6 are more reliable as done on uncorroded parts)

TABLE 25

Percentage Composition*

Site : Mohenjodaro Based on (Mar 31)

Sample details		Sn	Ni	Sample details		Sn	Ni
Late period				Late period			
D. K.	3479	—	—	D.K.	4059	—	0.15
,,	4585	10.2	—	,,	4087	—	0.26
,,	4378	—	—	,,	4068	10.7	Tr
,,	3833	—	—	,,	4041	—	Tr
,,	4568	10.3	Tr	,,	3648	—	Tr
,,	4588	14.6	—	,,	3612	—	Tr
,,	3735	—	Tr	,,	3630	11.6	Tr
,,	4035	—	Tr	,,	3611	—	0.14
,,	4005	—	Tr	,,	3712	—	0.24
,,	3741	—	0.22	,,	4599	—	0.04
,,	3979	—	Tr	,,	4600	5.6	0.21
,,	3992	—	Tr	,,	4396	—	0.05
,,	3955	—	Tr	,,	4400	—	0.07
,,	3914	—	—	,,	4361	19.1	Tr
,,	3956	—	Tr	,,	4451	—	—
,,	3935	—	Tr	,,	4303	—	Tr
,,	3849	—	Tr	,,	4431	—	—
,,	3843	—	Tr	,,	4565	—	Tr
,,	3756	—	0.68	,,	4585	—	Tr
,,	3748	—	Tr	,,	4330	—	Tr
,,	4128	—	0.86	,,	4384	—	—
,,	3846	—	Tr	,,	4260	—	—
,,	4185	—	Tr	,,	3566	—	0.81
,,	4173	—	0.51	,,	4642	—	—

---

* Balance was copper.

TABLE 26

Percentage Composition

Key : +=persent.
Tr=trace.

Site : Mohenjodaro

Based on (Mar 31)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu*	Sn	Ni	S	REL. PROB. % I	II	III
1. S.D. 1405	—	—	—	—	0.36	—	—	—	0.17	6.78	5	84	11
2. S.D. 1932	—	—	—	—	Tr	—	—	—	9.38	1.73	47	51	2
3. L. 3767	—	—	—	—	0.30	—	—	—	3.34	7.77	5	84	11
4. S.D. 2683(A)	—	—	—	—	+	—	—	—	Tr	—	47	51	2
5. S.D. 2683(B)	—	—	—	—	—	—	—	—	—	—	,,	,,	,,
6. S.D. 2683(C)	—	—	—	—	—	—	—	—	Tr	2.63	,,	,,	,,
7. L. (?)	—	—	—	—	—	—	—	—	1.04	2.40	,,	,,	,,
8. H.R. 1152	—	—	—	—	—	—	—	—	0.39	0.32	,,	,,	,,
9. E. 602	—	—	—	—	—	—	—	14.4	Tr	—	,,	,,	,,
10. H.R. 1472	—	—	—	—	—	—	—	—	1.49	0.23	,,	,,	,,
11. V.S. 1572	—	—	—	—	—	—	—	19.0	0.23	0.43	,,	,,	,,
12. V.S. 1416	—	—	—	—	—	—	—	—	0.09	0.28	,,	,,	,,
13. D.K. 542	—	—	—	—	—	—	—	—	0.30	0.34	,,	,,	,,
14. D.K. 1679	—	—	—	—	+	—	—	—	Tr	0.05	,,	,,	,,
15. D.K. 2155	—	—	—	—	+	—	—	—	0.53	0.03	,,	,,	,,

* Balance copper

TABLE 27*

Type	Spear head	Knife	Axe	Sword	Chisel	Fish hook	Saw	Razor	Axe-adze	Arrow head	Sickle	Grand total	Per cent
Upper levels:													
Total	9	31	13	2	36	5	2	12	1	7	—	118	
Copper	8	24	8	2	28	2	1	11	—	7	—	91	77
Bronze	1	7	5	—	8	3	1	1	1	—	—	27	23
Lower levels:													
Total	5	33	10	—	17	6	—	6	—	10	1	88	
Copper	5	33	7	—	15	6	—	6	—	10	1	83	94
Bronze	—	—	3	—	2	—	—	—	—	—	—	5	6

* Shows the rich tool-repertoire from the further excavations of the DK-mound of Mohenjodaro alone. In the upper levels 23 per cent of the tools are of bronze, whereas in the lower levels they are only 6 per cent [based on (M 37-38)].

TABLE 28

Percentage Composition

Site : Rangpur

Based on (Rao 63)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	O_2	REL. PROB. % I	II	III
1. 324 Celt Pd IIc	—	—	—	—	Tr	—	91.2	2.6	2.1	4.1	47	51	2
2. 663 Celt Pd IIa	—	—	Tr	—	Tr	—	91.35	4.09	Tr	4.6	,,	,,	,,
3. 437 Bangle Pd II	—	—	Tr	—	Tr	—	86.4	11.07	1.8	0.73	,,	,,	,,
4. 417 Knife Pd IIc	—	Tr	—	—	—	—	94.8	0.7	0.4	4.1	,,	,,	,,
5. 330 Pin Pd III	—	1.88	—	—	—	—	91.8	0.6	5.88	—	8	84	8
6. 442 Pin Pd IIB	—	1.86	—	—	—	—	96.6	Tr	0.8	0.74	,,	,,	,,
7. 260 Bead Pd IIa	—	1.4	—	—	—	—	96.66	Tr	0.38	1.56	,,	,,	,,
8. 635 Ring Pd IIa	—	0.45	—	—	—	—	96.1	Tr	0.2	3.25	52	25	23
9. 169 Bangle ?	—	Tr	—	—	—	—	57.7	6.94	Tr	35.46	47	51	2
10. 170 Amulet Pd IIa	—	0.57	—	—	—	—	77.6	Tr	0.1	21.73	52	25	23
11. 141 Pin Pd IIa	—	0.24	—	—	—	—	65.4	6.78	0.51	27.08	26	56	18
12. 526 Knife Pd IIc	—	Tr	—	—	—	—	59.0	5.28	Tr	35.72	47	51	2
13. 525 Knife ?	—	1.08	—	—	—	—	59.6	2.69	—	36.63	8	84	8

(BN 51) said that tin varies from 0-8.5% from tools of the phases G, H and I. Copper in Phase F was however free of tin.

In India

Not many analyses are available from the Pre-Harappan sites. In Mundigak a low-tin (1.06%) bronze (?) is reported (Table 24). Another object from Nal (Table 30) does not show any tin, but lead therein is 2.14%.

In the Harappan artifacts (Tables 12, 13, 17, 18, 19, 25, 26) tin percentage varies greatly:

Tools	70%,	10%,	14%,	6%
Tin content :	1%,	8%,	8-12%,	12%

It is clear from the above that 70% of the tools were not alloyed. And only 14% were alloyed correctly in the range of 8-12% tin for optimum strength and ductility. In a bronze rod the tin percentage was more than 22. It is clear that though the alloying was understood, correct proportions could not be controlled. It may be due to the mixing of arsenic in ore form. Lollingite (iron-arsenic ore) is reported from Nal (Table 20) and could have been used.

I worked out the relative abundance of bronze from Mohenjodaro upper and lower levels (Table 27): It is more abundant (23% tools of bronze) in the upper levels and less in the lower levels (6%).

It appears that mainly knives, axes and chisels (Table 27) were made of tin-bronze. But the fact that 70% of the tools were of copper only shows that tin was scarce.

From Rangpur (Table 28) only 6 artifacts show tin 2.6 to 11%; three have nickel ranging between 1.8 to 5.8%. None had lead or arsenic.

Out of the 177 analyses of artifacts from Mohenjodaro and Harappa, which were studied by me, only 8% tools show arsenic (1-7%) alloying, only 4% nickel (1-9%) alloying and only 6% indicate lead (1-32%) alloying. Even about 1% of arsenic increases the hardness of copper from 124 to 177 (Br. H. Nos.)—in hammered condition. In view of this property, the fact that only 8% tools were arsenic-alloys may betray their ignorance of it or the poverty of the metal. It is quite likely that arsenic was added only as a deoxidiser for closed castings, e.g. fulcrum bar (Table 18).

In the copper artifacts from the Chalcolithic sites (Table 21) no arsenic alloying is indicated. Lead is common and varies

TABLE 29

Percentage Composition

Sites : Sonpur and Chirand — Based on (Ve 68)

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Sio_2	Done by
Sonpur spoon handle SPRXV No. 335 (1962) Layer 3, Depth—3′5″ Pd II	—	—	—	—	—	—	64.89	32.42	2.69	(Chemistry Dept. Patna Univ.)
Bangle fragment SPR XIII No. 241 (1962) Layer 5, Depth-7′8″ Pd II	—	—	—	—	6.985	—	87.98	1.887	3.248	,,
Rod SPR VII No. 130 (1959) Layer 14, Depth-22′ Pd IA	—	—	—	—	—	—	98.43	1.397	0.173	,,
Chirand CD 470	—	Tr	—	—	—	—	99.7	—	—	(Central Forensic Science Lab. Calcutta)
CD 741	—	—	—	—	—	—	100	—	—	,,
CD 472	—	—	—	—	—	—	99.84	—	—	,,

TABLE 30

Percentage Composition

Miscellaneous Sites

Sample details	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	Mn	Co	Cr	REL.PROB. %			Reference
														I	II	III	
Hastinapur No. HST-1-1126, Pd II	—	0.38	0.48	—	0.10	—	97.95	0.40	0.38	—	—	—	—	0	26	74	(Lal 54-55)
Hastinapur No. HST-1-1585, Pd II	—	0.52	0.34	—	0.10	—	97.89	0.63	0.20	0.55	—	—	—	0	55	45	,,
Nal, adze fragment No.38, from D area, Surface	—	—	Tr	—	2.14	—	93.05	—	4.90	—	—	—	—	5	92	3	(Ha 29)
Tekklakota Axe	—	1.23	—	—	1.12	—	96.79	—	0.37	—	Tr	0.28	Tr	0	92	8	(Na 65)
Langhnaj Knife	—	0.61	Tr	—	0.28	Tr	98.12	—	0.48	—	—	0.18	—	1	75	24	(He 64)

from 1-2% and probably was a deliberate addition for better fusibility. As regards tin, a Jorwe axe has 1.78%, a Nevasa chisel has 2.7%, all the three Navdatoli objects have it within 3-5 %, and the Somnath axe has the maximum, 1[illegible]8%. It is clear that the tin alloying was known to these people, though except for the Somnath example no object shows tin concentration in the optimum range of 8-12%. Tin is significant by its absence in the Ahar objects.

It may also be noted here that no tin or arsenic alloying is indicated by the analysis of a Tekklakota axe and a Langhnaj knife, nor by the two objects from the P. G. Ware levels of Hastinapur (Table 30). In Sonpur Pd I tin in a rod is 1.4% and in Pd II in a bangle it is 1.9%, while in the spoon handle it is 32%. All the three objects from Chirand are of pure copper (Table 29).

Thus we see that the high range of tin, lead and arsenic alloying of the Harappans stands apart from that of the Chalcolithic objects. In the latter, arsenic alloying is absent and tin content does not exceed 5% (except in the Somnath axe).

Lal (Lal 51) had emphasised that the Copper Hoards were of pure copper in contrast to the use of bronze in the western socketed axe, adze etc. Smith (Smi 05) however had mentioned the following examples of bronze:

(i) Strachey celt from Jabalpur	13. 3% tin
(ii) Elliot sword	3.83% ,,
(iii) Norham harpoon	7.97% ,,
(iv) Elliot harpoon	6.74% ,,

Lal (in Lal 51) analysed the Bisauli anthropomorph and found it to be unalloyed:

Copper—98.77%; Nickel—0.66%.

The five Copper Hoard specimens (Shahabad celt, Shahabad harpoon (?) fragment, Kamdera celt, Dhanbad celt, and Dargoma celt) examined* by us also showed absence of tin.

Thus the present evidence favours Lal's view that the Copper Hoards' people did not know alloying. Smith's samples were taken mostly from British museums and their find spots too were not definitely known. Hence one can't rely on them much.

On the basis of the available evidence we can thus tentatively infer that : (i) the Harappans used deliberate arsenic, lead and tin alloying; (ii) the Banasians were adding lead only; (iii) the Malwa and Jorwe cultures were using lead and tin alloying and; (iv) the Copper Hoards were probably of pure copper only.

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* Work on the Copper Hoard artifacts and various ores is being continued by us on an extensive scale. The data at present are not enough to present any conclusions.

5. iv. *Ore-correlations*

To try to determine the types of ores used, we calculated their relative probabilities on the basis of the chemical data given here in various tables. The approach and procedure were explained before (Sec. I. E.).

At Harappa (Table 19) the probability of the use of oxide ores (e.g., malachite) only is very high. In the early levels of Mohenjodaro (Table 13) too the probability of the use of native or oxide ores is high. Table 17 shows, however, that even in the early levels of Mohenjodaro sulphide ores (e.g. chalcopyrite) probably were being smelted. Though on the whole in Mohenjodaro (Tables 13, 14, 17, 18, 26) and Rangpur (Table 28) native and oxide ores were probably in common use.

Native copper and oxide minerals generally occur on the surface outcrops of ore-bodies. The preponderance of native and oxide forms thus may indicate use of fresh mines. Exclusive use of native or oxide minerals at Rangpur makes the use of fresh mines (e.g., Rupawati in Kathiawar) quite probable.

Large quantities of copper oxide ore* (along with some lead) were recovered from a brick lined pit, 5′ 6″ × 4′ 3″ × 4 6″, in room 51, DK area at Mohenjodaro (M 37-38). It was analysed by Desch (Table 20). This discovery further proves the use of oxide ores for smelting by the Indus smiths. Though they could obtain quite pure copper from sulphide ores right from the start.

Thus we can infer the availability of fresh mines which could provide native and oxide minerals to the Harappans, though they had the technology to smelt sulphide ores from the early phase itself.

On the other hand the 13 analyses of the Chalcolithic artifacts so far do not indicate any probability of the use of sulphide ores (Table 21), though there is a very high probability of the oxide ores being used.

If we take into account the poor casting, the simple shapes, the relative scarcity of metal (as compared to the Harappans), the absence of sulphide ore-smelting and arsenic alloying, and the poor content of tin (less than 5%) in the Chalcolithic bronzes, the contrast with the developed Harappan metallurgy becomes quite glaring.

The distinct identities of the Harappan and the Chalcolithic metallurgical traditions preclude the probability of any direct

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* Despite my best efforts, I could not acquire this ore for analyses.

TABLE 31

Spectroscopic Analyses*

Key : + =present
nd =not detected
ns =not seen

Chalcolithic Sites

Sample Description	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	Mn	Co	Au	Al	Cr	Mo	Zr	W	Ti	Mg	V	Gd	P	Si
1. Navdatoli Axe	+	+	+	nd	+	+	+	+	+	+	+	+	nd	+	+	+	+	nd	+	nd	+	+	nd	nd
2. Navdatoli Chisel	nd	+	+	nd	+	+	+	+	+	+	+	+	nd	+	+	+	+	nd	+	nd	+	+	nd	nd
3. Chandoli Axe	nd	+	+	nd	+	+	+	nd	+	+	+	+	nd	+	+	+	+	+	+	+	+	+	nd	nd
4. Somnath Axe	nd	+	+	nd	+	+	+	+	+	+	+	+	nd	+	+	+	+	+	+	nd	nd	+	nd	nd
5. Ahar Axe	nd	+	+	+	+	+	+	nd	+	+	+	+	nd	+	+	+	+	nd	+	+	nd	+	+	+
6. Ahar Metal Sheet	nd	+	+	+	+	+	+	nd	+	+	+	+	nd	+	+	+	+	nd	+	+	nd	+	+	+
7. Khetri Ore	nd	+	+	+	+	+	+	nd	+	+	+	+	nd	+	+	+	+	+	+	+	+	+	+	+
8. Nevasa Chisel 6721	+	+	+	ns	+	+	+	+	+	+	+	ns	ns	+	ns	ns	ns	ns	ns	+	ns	ns	ns	+
9. Nevasa Bangle 6722	+	+	ns	ns	+	+	+	+	+	+	+	ns	ns	+	ns	ns	ns	ns	ns	+	ns	ns	ns	+
10 . Nevasa Bead 6723	ns	+	ns	ns	+	ns	+	+	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	+	ns	ns	ns	ns

* Nos. 1 to 7 based on (He the) and 8 to 10 on (SDA 60).

TABLE 32

Spectroscopic Analyses*

Indian Ores and Artifacts

Key : + =present
nd =not detected
ns =not seen

Sample Description	Ag	Fe	As	Sb	Pb	Bi	Cu	Sn	Ni	Zn	Mn	Co	Au	Al	Cr	Mo	Zr	W	Ti	Mg	V	Gd	P	Si
TF-Cu-14a Madras Pyrrhotite	nd	+	nd	nd	nd	nd	+	nd	+	+	nd	+	ns	nd	nd	nd	nd	+	nd	nd	nd	ns	ns	nd
TF-Cu-14b Madras Pyrrhotite	nd	+	nd	nd	nd	nd	+	nd	+	+	nd	+	ns	nd	nd	nd	nd	+	nd	nd	+	ns	ns	nd
TF-Cu-5 Mohenjodaro Galena Ore	nd	nd	nd	+	+	nd	nd	nd	nd	nd	nd	nd	ns	nd	nd	nd	nd	nd	nd	nd	nd	ns	ns	nd
TF-Cu-15 Singbhum Chalcopyrite	nd	+	nd	nd	nd	nd	+	nd	+	+	+	+	nd	+	nd	+	ns	ns	+	+	+	ns	ns	+
TF-Cu-24 Khetri Chalcopyrite	+	+	+	+	+	+	+	+	+	+	+	+	nd	+	+	+	ns	ns	+	+	+	ns	ns	+
TF-Cu-3 Chanhudaro celt	+	+	+	+	+	+	+	+	+	+	+	+	nd	+	+	+	ns	ns	+	+	+	ns	ns	+
TF-Cu-6 Mohenjodaro spearhead	+	+	+	+	+	+	+	+	+	+	+	+	nd	+	+	+	ns	ns	+	+	+	ns	ns	ns

* My samples

transmission. There is a clear set-back in the Chalcolithic technology.

The relative probabilities for the use of different types of ores for the P. G. Ware, associated and neolithic artifacts are indicated in Table 30; but the data are meagre.

Mining areas

To determine the mining areas used by different cultures is more difficult and requires a large number of samples. So far only a few ore-samples could be obtained*, and examined (Table 32). Chalcopyrites, both from Khetri and Singhbhum, pyrrhotite from Madras, and galena from Mohenjodaro were analysed.

It is important to note that Singbhum pyrites showed absence of arsenic, antimony and lead, which are present in significant amounts in the Harappan artifacts.

A closer comparison of the impurity patterns of the spectroscopic analyses (Table 32) of the Harappan artifacts and various ores shows that there is a close correspondence with the Khetri ores. Singbhum chalcopyrites and Madras pyrrhotite are quite dissimilar. So if we can base any conclusions on the few analyses done so far, Khetri belt is more probable a mining area for the Harappans. It is further supported by the use of mostly oxide and native minerals, which could be available in plenty in a virgin mine. Singbhum mines were too far off and the thick forests intervened in between, and are thus precluded as a likely source.

A comparison of the spectroscopic analyses (He the) of the Chalcolithic artifacts with the Khetri ore also shows a good correspondence (Table 31). Of course a much larger number of ore analyses are required to arrive at definite conclusions. At present we can only say that the Rajasthan ores were probably used by both the Harappans and the Chalcolithic people. This source alone can justify the import of 'copper from Meluhha' in Mesopotamia (Le 59).

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* Further work in this line is being continued by us on a long term basis.

CHAPTER 6

METAL FORGING TECHNIQUES AND TYPOLOGY

In the previous chapter we discussed how copper was mined, smelted and alloyed. In this chapter we will now discuss the metal forging techniques, which are generally characteristic for a particular culture, and the functional typology.

A detailed study of the metal forging techniques is a desideratum to study the differences as also the affinities between different protohistoric cultures. Since metallurgical know-how comes to India very late, as compared to Iraq and Iran, we find a full-blown metal-technology in the Harappa culture without the developmental—hence distinctive—stages there.

A detailed study of such techniques is impeded by the reluctance of the collectors to supply samples for metallographic studies. However, the limited data that we have been able to collect, at the moment, do throw some light on the problems formulated in Chapter 2.

In this chapter we will discuss metal forging techniques (Sec. I. A.), metallographic detection (Sec. I.B.) and results (Sec. I.C.). A brief typological analyses with due regard to functional aspects will be attempted (Sec. II) and in the final part (Sec. III) conclusions would be given. The Copper Hoards problem will also be discussed (Sec. II).

6. I. *Metal Forging and Detection*

I. A. THE TECHNIQUES

Described below are the various techniques of metal forging that were used in the ancient world, with special reference to India.

Hammering

Hammering is an essential technique for cold and hot work in making vessels wires, and other artifacts. Ingots were beaten to desired shapes. Nowadays a variety of grades of steel hammers are available for beating the bronze sheets. But in old times only worn pebbles were used and it was a wrist shattering experience.

In the Tomb of Rekhmare (*ca.* 1450 B. C.) a metal worker is actually shown using a pebble hammer (Ch 44, Fig. 3). The same figure depicts the techniques of 'raising' and 'sinking'.

When a vessel is made by hammering from inside—it is called sinking, blocking or hollowing. Generally it was done over a shallow concave depression cut into a wooden anvil. In 'raising', the opposite was done : the vessel was kept over a dome-beaded stake and beaten from outside.

In the beginning wires were formed by hammering down a narrow bronze rod; the results were mostly uneven. Later, in wire drawing, rods were passed through a plate with a series of progressively smaller holes and a draw plate was used which repeatedly lengthened the rod and reduced the diameter. This was an advanced technique. In Troy II wire drawing is attested (For 64a). A copper wire from King Zoser's tomb has also been reported (For 64a). But no wire drawing is attested to in the protohistoric India.

During the earliest phase native copper was shaped by hammering and grinding, techniques known from the Stone Age. Even the fine gold leaves were made with such pebbles (A 60).

Mackay (in Mar 31) held that pure copper vessels were made by beating, as their shapes are simple. For example, stake marks and hammer marks are clearly seen in the vessel No. 22, Pl. CXVIII (M 37-38). Objects with thin section (M 37-38) like razors knives, spearheads, arrows, and saw etc. were probably chiselled from a sheet of copper. Such saws must have been essential for heavy woodwork.

The Harappan tubular drills (M 43, Pl. LXII, LXXX, 9, LXXXI, 15) are in the form of tapered tubes of thin metal and are so carefully made, without the edges overlapping in any way, that the use of mandrel for hammering a jointless cast ring is clearly indicated.

Spinning

Spinning and turning are essentially mechanical methods depending upon the use of lathe and have so far not been attested to in the period covered here. Mackay (in Mar. 31, Pl. CXL, 4 and 5) however had suggested that dishes and covers were made by turning on lathe. But there are no lathe marks left to decide it.

Cold work

Cold work is hammering done on cold metal (below recrystallisation temperature). The cast objects of pure copper are as a rule soft. By cold hammering they can be made much harder (from 87 of pure copper to 135 Brinell hardness numbers). Treated thus such tools may approach the hardness of mild steel. But too much of hammering makes them brittle and easily breakable. To avoid that, the tools had to be heated to make them ductile and malleable again. Alloying increases the hardness considerably. Since upto 16% tin is in solid solution (6.I.B.), the effect of cold work is enhanced in making it harder.

It appears that the ancients did believe in 'quenching' bronze in the waters of certain wells to increase their hardness. The Bureau of Mines (U. S. A.) has however definitely proved that the only way of hardening copper is by cold hammering (For 64a).

Cold work is attested to in the Harappan and Chalcolithic artifacts.

Hot work

Copper may be worked at any temperature upto 1050°C. The essential thing is that the temperature of the metal must be kept above recrystallisation temperature (when the metal gets deformed). Today most hot working operations begin with the metal at about 850°C and finishing temperature of about 400-500°C. Hot working refines the coarse grains found in cast copper and increases the density of the metal by closing up small pores and gas holes. Otherwise, it has no effect on ductility, strength and hardness (NW 42). In antiquity, this was probably used to avoid brittleness caused by cold work.

Annealing

This process of heating a cold-worked brittle metal to regain its malleability—known as annealing—was not a very well-known technique in many old societies. For example, Garland and Bannister (GB 27) did not come across any evidence of annealing in Egypt before Greco-Roman times.

Most commercial annealing today is done at 590°C which provides the necessary softening action without promoting undue grain growth (NW 42).

Shortly after *ca.* 5000 B. C. this technique was probably discovered. Aitchison (A 60) has reported bits of softened copper at Sialk and Hassuna. Annealing is known from the Harappa culture (Mar 31, Ch 57) and the other Chalcolithic cultures too, though perhaps not to the authors of the Copper Hoards.

Joining Methods

The old method of joining two metals was to pour molten bronze on the part to be joined. If the parts to be joined were quite clean, the fresh molten bronze would fuse with them. This was known as 'running on', 'casting on', or 'burning on'. This method was also used to join two differently made parts of an artifact, e.g. a tanged sword and its hilt.

Rivets have been used both to join metals and non-metallic objects. Early rivets were simply short lengths of metal rod hammered down at both ends, but properly formed rivets with domed, pan or conical-shaped heads were clearly soon appreciated for their greater strength and decorative value (Ho. 65). Rivetting and caulking was known from early times as shown by the rivetted statue of King Pepi I (*ca.* 2300 B. C.) with copper bolt (For 64a). Rivetting is known in the Harappa culture (Mar 31; Ch 57), so also lapping of tubular handles (M 37-38; Pl. CXXII).

Soldering is the use of a different alloy to join two pieces of metal, as this has the advantage that one can work well below the melting point of the metals being joined. In many alloys the eutectic component has a lower melting point than any of the others. Thus an alloy of 55% copper and 45% zinc, 'hard solder' or 'brazing spelter', has a somewhat lower melting point than 70 : 30 yellow brass; while an alloy of 67% lead and 33% tin, 'soft solder' or 'lead solder', has a far lower melting point than either lead or tin. The soft solder can either be applied with a heated 'iron' or be placed in position between the pieces to be joined and then the whole heated till the solder melted. To prevent oxidising the metal surfaces during heating a flux, most commonly tallow or animal fat for soft solder and borax for hard solder (Ho 65), was used. Gold beads from the Royal Graves of Ur attest to soldering. It was known in Old Kingdom Egypt and 'al Ubaid period (For 64a). Though evidence of copper soldering is not available from Indus sites, gold and silver soldering are known according to Sanahullah (in Va 40; Ch 57). 'Running on' is reported from several vessels from Mohenjodaro (Mar 31).

Welding can be done in three ways:

(i) Pressure welding, cold or hot, without fusion;

(ii) Sweating or surface welding without pressure: the areas to be joined were clamped together with the solder in between and heated; and

(iii) Fusion welding which involves heating the metal to somewhere near melting point and hammering them, so causing them to fuse. It is very difficult to achieve due to the rapidity of oxidation of the surfaces to be joined. This method was seldom used in antiquity. True welding (ferrous) is attested to in the head-rest of Tutenkhamen (For 64a).

Garland and Bannister (GB 27) however held that there was no positive evidence of welding, brazing of copper or bronze, or of soft soldering before late Roman times in Egypt. Nor is any real welding known from the Indian protohistoric sites.

Casting

We can define broadly three categories in casting (For 64a; Ty 62; Cog 54; Ho 65).

(i) Open casts;
(ii) Part moulds or closed moulds; and
(iii) Lost wax process (*cire perdue*).

Open moulds consist of a depression made in the mould material to receive the molten metal. Stone for this purpose was so selected that it did not alter at high temperature, e.g. soapstone or fine grained argillaceous sandstone. Refractory clay was also used (Ho 65). The moulds till the Early British Bronze Age were of stone only. Possibly these moulds were closed with flat movable covers to allow slow cooling (Ty 62). The Harappan flat axes were cast in open mould and then worked unlike the Gungeria axes, where they have ridges on the edges showing use of double moulds. Open stone moulds are reported from Chanhudaro (M 43) also.

Closed moulds were made of two or more fitting pieces of stone, clay or bronze. Accurate registration of the pieces being ensured by means of opposing holes into which were fitted dowel-rods. Sometimes spruce cups were added over the moulds through which was poured the molten metal. This is to counteract the contraction in the inner part of the artifacts which cools later than the portions coming in contact with the mould walls. Runners and risers too were devised to fill little extra metal in the mould so that the gases rise to the riser which can be cut off later. To save metal, cores were used. From before 2600 B. C. three to four piece moulds are reported from Ur (A 60). In Mesopotamia oiled sand and bituminous mixtures were used for cores. The joint lines or 'flashes', where not removed by planishing, are tell-tale marks of the closed moulds.

Closed casting with pure copper was very difficult hence we rarely get such pieces. It could be possible only with sufficient head of metal and adequate venting of the mould. Since core casting was unusual with copper, the typical copper spear has a tang for its attachment to the shaft. Sockets were also made by folding flat tangs into the form of a conical tube (Cog 54).

I examined many harpoons to see if any ridges are left on the sides. of the tool denoting use of double moulds. Two barbs in the Shahjahanpur specimen and three in the Shahabad specimen showed such ridges. Gungeria axes too showed these tell-tale ridges. Generally there is a hole in the last blunt barb of the harpoons. Some of the specimens (TF-Cu-12) clearly showed that these were cut later. Could they have served as risers for better casting.

When metals are heated in furnaces, they absorb gases (e.g. CO, CO_2, H_2S) from the fuel. Most deleterious is water vapour which comes from the combustion of hydrogen in the fuel. The water vapour formed is reduced by the metal being melted ($2\ Cu+H_2O=Cu_2O+H_2$) and the hydrogen so formed readily enters the metal. It stays dissolved until solidification, when it comes out as gas bubbles causing gas holes that spoil the casting.

If blister copper is used it has several occlusions and blow holes. If it is cast in this form it has too much of cuprous oxide which makes it very brittle. To avoid this the molten metal is 'poled' with green wooden boughs, the hydrocarbons (to a lesser extent wood carbon also) thus evolved reduce the oxide. Correctly poled copper is called tough pitch copper. If however the poling is over done, the reducing hydrogen from the 'poling' goes into the copper and makes it brittle. On casting, this hydrogen also will create blow holes (Ho 65). By the provision of larger feeders and risers viz. surplus masses of metals, the gas in a copper casting may be allowed to rise to the top into a part of the casting, which can be discarded.

It is because of the ease of open mould casting that we have mostly flat axes and very simple tools in the Indus. Puckered surfaces of axes from Chanhudaro (M 43, Pl. CXX, 27) show bad casting. From Mohenjodaro some of them are worse, with so many blow holes (M 37-38, Pl. CXXXII, 36, 40) that they could never be used.

Cire perdue or lost wax process is quite developed one and is used for casting complex shapes. It was known to the Harappans (Mar 31; For 64a; Ch 57), though Sanahullah thinks otherwise. Figures like that of the dancing girl clearly show use of this method.

The lost wax method consisted (Fig. 14) of making a wax model over a clay core, the thickness of the wax corresponding to the thickness of the metal required. Over this a single outer mould of clay was built up, incorporating the sprue cup, runner, risers and vents. The whole was then heated to melt the wax which was allowed to run out. This would shift the core; to avoid it chaplets were used (Fig. 14) which held the core to the outer mould (ultimately they became part of the final cast object). Then molten metal was poured. The mould of course had to be broken and could not be used. Core sometimes remained, sometimes raked out.

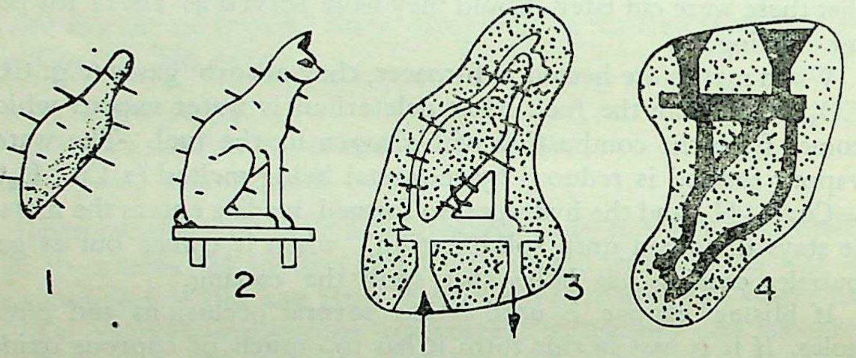

Fig. 14. The stages in casting by *cire perdue* (lost wax) method. The wax model (2) of the sculpture is prepared over a clay core (1). The model is again covered with thick clay (3) bearing two holes as inlet and outlet for molten metal. The mould is upturned and filled with molten metal (4) the liquid wax comes out of the outlet as also the surplus metal. The mould is broken when the metal solidifies.

"Three complex statues from Tell-Asmar had been successfully made by lost wax process. . . in copper that Desch has shown to contain only 0.63% tin. Closed moulds were used in making the copper castings of lion heads at the temple of A-Anni-Padda at Al' Ubaid, which were made about 2700 B. C." (A 60). This was possible only because of tin and arsenic impurities which helped counter gassing of copper. In Egypt this method was known by *ca.* 2500 B. C. (A 60; GB 27). Still, closed casting in copper was a difficult thing to achieve.

In 'slush-casting', mould is filled with molten metal which solidifies as soon as it comes in contact with mould walls, but the central portions remain liquid. This is quickly upturned and the remaining molten metal was poured out, (A 60). This gave rise to hollow castings.

I. B. METALLOGRAPHIC DETECTION

Before presenting the results, it would be useful to understand the technique of metallographic detection.

Every metal has a crystal structure which when studied under magnification yields valuable information regarding the metal forging techniques used on it. In the Indian context such studies have a great significance. Metallographic studies, like detective work, give clues about the techniques used by the ancients in forging the artifacts. On the basis of the available metallographic data (ours as also of other workers) we would determine the distinctive techniques used by the different protohistoric cultures. In conjunction with the conclusions drawn from the chemical data, we would assess if these data can give us some clues towards the solution of problems posed earlier (Chapter 2).

A suitable surface is prepared on the artifact to be examined by mirror-polishing it. Various grades of emery papers are used for rubbing and polishing—changing from coarse to fine grades of papers. It is essential to rub each time at 90° to the direction of previous rubbing—this eliminates marks or striations caused by paper. Too much pressure may generate heat and bring about structural changes in the metal and hence should be avoided. Finally the surface is washed and cleaned of all grit and dressed with Brasso or better still diamond powder. It is always better to examine a metal at this stage to look for flaws (crooks), inclusions of slags, lead, cuprous oxide etc. before the surface is etched.

Normal etching, for non-ferrous metals, is done with 10% of ferric chloride acidified with 2% hydrochloric acid. Over etching should be avoided, otherwise the whole process has to be repeated again. Etching provides colouration and easy detection of changes and crystal structure. Final washing and thorough drying are essential before examining the sample surface.

The size and shape of grain in a cast object and the deformation by the elongated shape of the grain is shown better by longitudinal section.

The cast metal is made up of primary crystal grains which do not have a regular geometric external form. Etching tints the surface and brings into view the crystal boundaries. When the molten metal is cast, solidification does not start all over uniformly. There are points or nuclei formed from which crystals grow radially outwards. This results in a three dimensional tree-like growth, called dendrites. While this process of solidification is continuing, the metal contracts and voids are formed near the dendrites. These voids are finely distributed and are called 'coring'. Dendritic growths and coring are distinctive of as-cast conditon of alloys in solid solution. By annealing the constituents (of solid solution) diffuse and the crystal structure looks like that of pure metal. In bronzes more than 8% of tin is shown as a second constituent in the as-cast condition. But annealing allows solid solutions of tin upto 16%. Beyond that a separate phase is formed which is called a eutectic.

Cold Work

Unlike tin (upto 16%) and arsenic (upto 4%), lead does not form a solid solution with copper but is distributed in the form of globules of gray colour. These globules do not turn red under polarised light, while cuprous oxide inclusions turn red and can thus be recognised. Such inclusions are flattened and elongated (Fig. 16) by the hammering of metals. Crystal grains are elongated also at right angles to the applied force (Fig. 17). In unannealed solid solutions (like less than 8% tin-bronze) the cores are also flattened and extended.

A cold hammered metal usually shows slip bands traversing the crystal grains, sensibly parallel in form. They are formed by the slipping of a part of the grain over other, in more than one direction. They are revealed by etching. A hammered alloy having 'cores' does not as a rule show slip bands very distinctly because the shaded margins tend to mask them. In an alloy consisting of a harder constituent than the other, they may not occur at all. They are seen best in bronze and brass specimens which have been thoroughly annealed before the work. Excessive cold work causes too confused a structure, no slip bands are visible then.

Cold work and annealing cause broad-bands which can be etched into light and grey portions. Cold work and annealing induce recrystallisation. As a result twinned grains are formed which are identical to the neighbouring grains except in the fact that they are rotated symmetrically about an axis so that they assume a mirror-image like position of the untwinned grains. After etching, these twinned grains look like light grey bands between the polygonal equiaxial grains.

Garland and Bannister (GB 27) were of the opinion that no recrystallisation is possible at room temperature whatever the length of period. Thomson (Tho 63), on the contrary, holds that in the case of pure metals when severely cold worked recrystallisation can take place e.g. in the gold nuggets hammered by the river gravel. "It is rarely possible, therefore, to do more than say in broad general terms that the metal with the longer grain size has been heated to the higher temperature or, alternatively, that it has

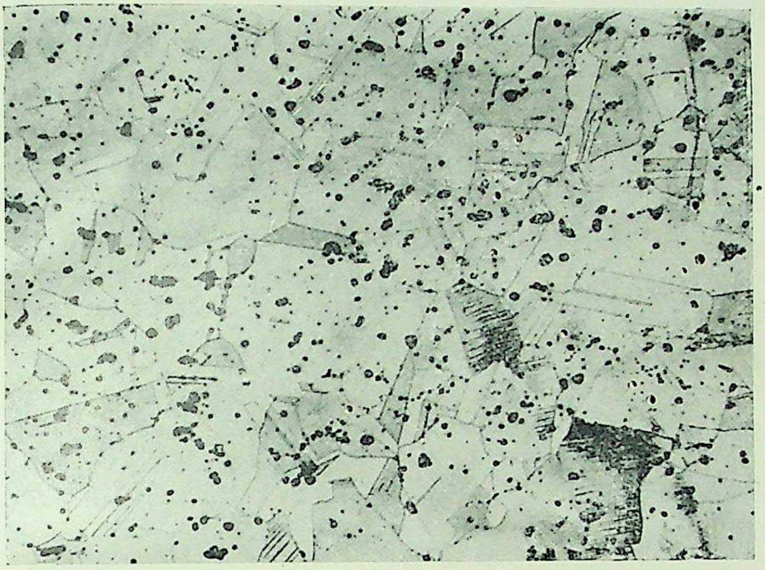

Fig. 15. Metallographic cross-section (× 60) of a Chanhudaro Copper Celt (TF-Cu-3). Polygonal grains with twins probably indicate cold-work and annealing. Inclusions of copper oxide can also be seen.

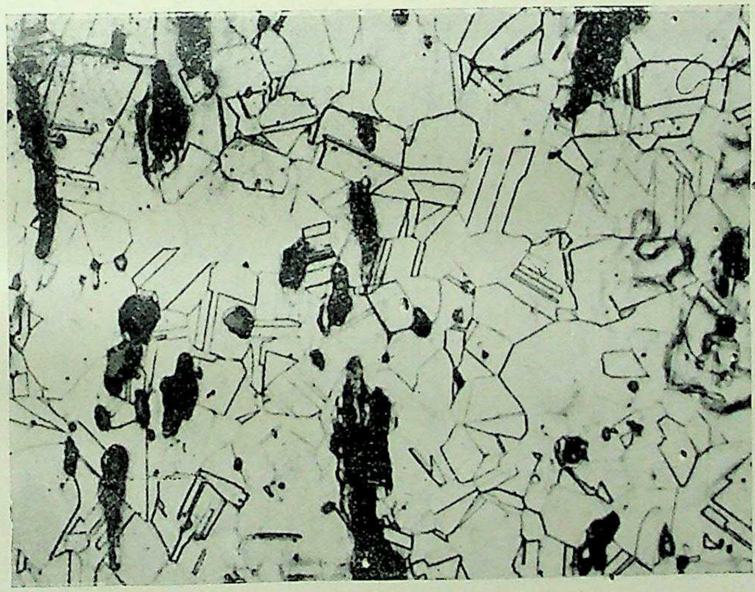

Fig. 16. Surface view (× 240) of etched copper wire from Chanhudaro (TF-Cu-8). Large pores at the centre may indicate a slow cooling while being cast. Twins in the grains indicate cold work and annealing.

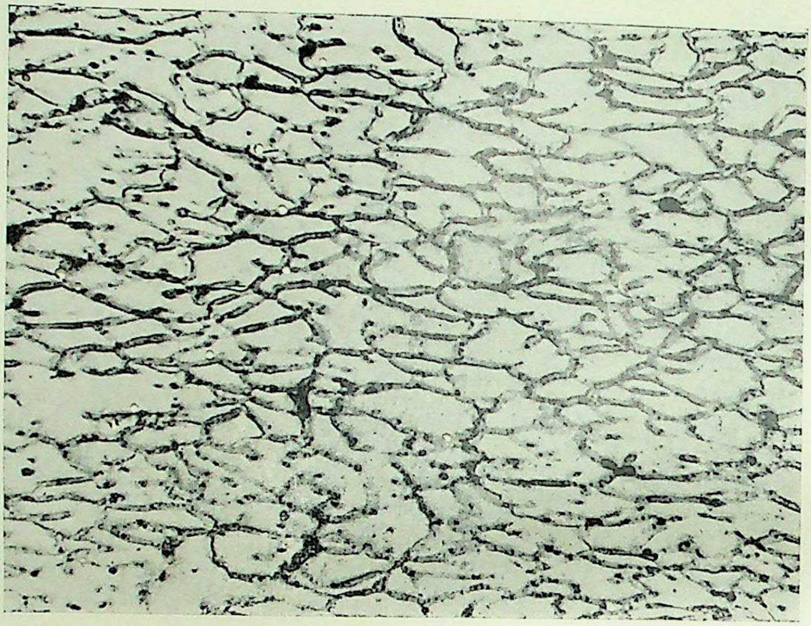

Fig. 17. Metallographic cross-section (× 60) of Shahabad Celt (TF-Cu-10) shows as-cast structure. Better ventilation and fast cooling are indicated.

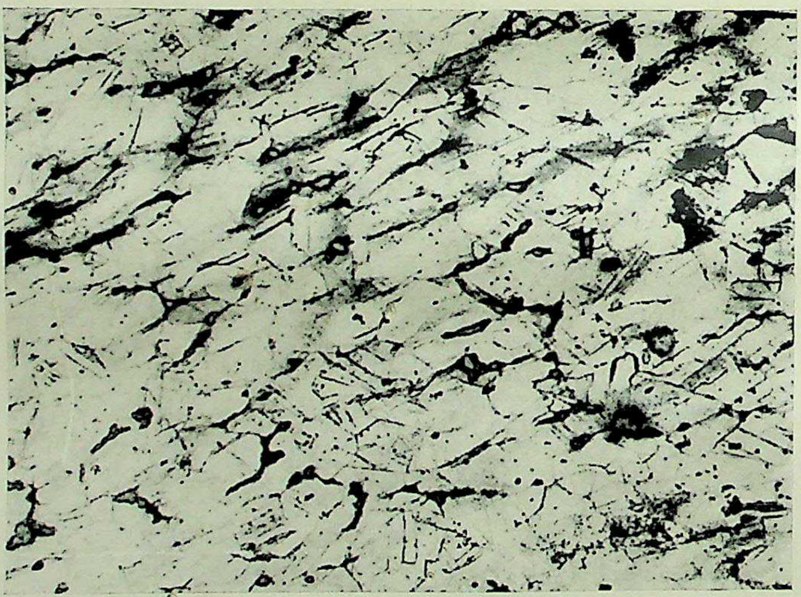

Fig. 18. Metallographic cross-section (× 160) of the edge of Shahjahanpur harpoon (TF-Cu-11) showing still unbroken cast structure. No annealing is indicated.

been kept there for a longer time" (Tho 63). But such cases as referred to by Thomson are extremely rare.

Annealing

Cold work brings about an equilibrium due to diffusion in the case of soluble metals and also induces recrystallisation. The new structure has jagged and irregular boundaries and the grains show much interpenetration, besides an obvious elongation in a direction at right angle to the cooling surfaces. One can be sure of recrystallisation if the grains present are considerably smaller than the spacing between the core lines.

I. C. METALLOGRAPHIC ANALYSIS RESULTS

Presented below are brief descriptions of the microstructures of the artifacts belonging to the Harappan, the Copper Hoard and the other Chalcolithic cultures. I have included here six of my Harappan samples and four of my Copper Hoard samples. I have also presented the results of Wright, Hegde and Pathak and Medhekar. In the concluding section (6.III) we will assess the significance of these results in the archaeological context.

(I) *HARAPPA CULTURE SAMPLES*

(a) *Chanbudaro Adze* (TF-Cu-1; A.S.I. No. 2593 (P)

Specimen (M 43, Pl. LXIV, 10) was too brittle and badly oxidised. The cross-section revealed a sandwiched type of appearance with many inclusions and pores. Though boundaries were revealed by etching, no reliable information regarding the method of fabrication could be inferred due to its badly oxidised condition. Inclusions mainly were copper oxide and sulphur.

(b) *Chanhudaro Celt* (TF-Cu-3; A.S.I. No. 2529 88)

Inclusions of copper oxide were seen. Small pores may indicate chill casting. Vickers Pyramid Hardness (VPN) numbers on the edge were 73 and on the body 69 thus showing lack of any remaining cold work. Polygonal grains with twins (Fig. 15) inside them show that after casting the celt (M 43, P. LXII, 22) was cold worked and annealed.

(c) *Chanhudaro Razor* (TF-Cu-4; A.S.I. No. 2593)

Due to high corrosion, a sandwiched appearance is revealed though boundaries of grains are visible due to etching. No other inferences are possible for this razor, (M 43, Pl, LXIV, 5).

(d) *Mohenjodaro Spearhead* (TF-Cu-6)

This is also badly oxidized hence no useful inference is possible.

(e) *Mohenjodaro Bowl* (TF-Cu-7)

Though quite corroded, structure shows both small and large grains with twins. This may indicate hot work. Lack of cracking and large pores may indicate that casting was done in a mould where cooling had been very slow.

(f) *Chanhudaro Wire* (TF-Cu-8; A.S.I. No. 49)

Inclusions appear (Fig. 16) elongated along the longitudinal axis of the wire. Large pores at the centre may indicate a slow cooling while being cast. Twins in the grains indicate cold work and subsequent annealing. No remaining cold work to be seen.

The first metallographic analyses of tools from Harappa (Va 40) were carried out by E. A. Wright, Metallurgical Inspector, Tatanagar. Sanahullah interpreted the microstructure as follows :

(g) No. 277a/21 is a sample of bronze in the cast condition and it is improbable that it has received any form of heat treatment Some cold work may have been done on it.

(h) No. X is a sample bronze in the annealed condition. It is probable that after casting the metal was subsequently heated and hammered, until, it reached a low temperature.

(II) *COPPER HOARD SAMPLES*

Given below are the results of my four samples belonging to the Copper Hoards.

(a) *Shahabad Broken Celt* (TF-Cu-10)

Examination of the surface and cross-section exhibits (Fig. 17) an elongation in cross-section, but the appearance of the structure as-cast indicates that the sample might not have been subjected to any other treatment after working. Hardness of the body (103 VPN) and the edge (129 VPN) are not very much different. Small pores, presence of coring and segregation of impurities indicates a fast cooling. Better ventilation of mould in the casting is indicated.

(b) *Shahabad Harpoon (?) tip* (TF-Cu-9)

The surface showed many inclusions (copper oxides etc.) and cracks. This made hardness measurements impossible. So Microhardness values were measured inside the grains. Edge gave

66 VPN and body 68 VPN. No preferential elongation of grains or pores in any particular direction may indicate beating in all the directions or no beating at all as the hardness measurements of the body and the edge are similar.

(c) *Shahabad Harpoon* (TF-Cu-12).

Samples were examined from the edge, middle of both surfaces and cross section. Working has removed the cast structure from the edges, though it is visible in the centre. Grains with twins inside are visible. Voids are also seen. Big pores may indicate slow cooling when cast. Subsequent working, however, has not completely broken down the cast structure nor caused complete recrystallisation. Edges show more hardness than the middle. Absence of annealing and use of cold work are indicated.

(d) *Shahjahanpur Harpoon* (TF-Cu-11).

Edge, middle of the surface and cross-sections were examined (Fig. 18). Edge shows grains with twins. No elongation of grains on the surface is seen, though cross section shows it. Despite the twins in the grains cast structure is not broken. Cooling seems to be rapid. A few twins are there though not completely recrystallised. Hence though cold work is indicated, no annealing was done.

III) *THE OTHER CHALCOLITHIC SAMPLES*

These samples were examined by Hegde (He the) and Pathak and Medhekar (in SD 55).

(a) *Chandoli Axe* (Specimen No. 1)

The surface is full of casting fins and free from forging fins. Surface is rough and corrugated, looks as though cast in a crude sand mould. The inclusions probably were due to lead and cuprous oxide (Table 21, No. 4, lead 1.68%). Absence of coring and presence of equiaxial grains show that metal is homogenous and cooled very slowly after casting and is in as-cast condition. Porosity holes show that casting was not good. Cuprous oxide inside the axe shows poor venting of the mould.

(b) *Somnath Axe* (Specimen No. 2)

Equiaxial grains and twinning are obvious; also slip and cross lines on the edge. But both cannot occur together. Slip lines disappear after annealing viz., recrystallisation of the grains. So twinning may indicate cold work and annealing. The slip-lines could have formed subsequently due to the use of the axe.

(c) *Navdatoli Axe* (Specimen No. 3)

The micro-structure shows equiaxial grains and twinning. The specimen was cold worked and annealed subsequently. The sample is from the butt-end.

(d) *Navdatoli Chisel* (Specimen No. 4)

The metal is free from porosity and cracks. The inclusions are distributed at random. It is a homogenous structure showing small grains and twinning indicative of cold work and annealing.

(e) *Ahar Axe* (Specimen No. 5)

Microstructure showed dendritic as also cellular structure and coring. The heterogeneity is due to presence of iron 6.4% and lead 1.62% (Table 21). Due to cracks and inclusions the microstructure is not clear, hence Hegde does not draw any conclusion regarding work and heat treatment. (Though in his fig. 15 I could see fine grains and twinning indicative of cold work and subsequent annealing).

Pathak and Medhekar (in SD 55) metallographically examined a copper axe and bangle from Jorwe excavations.

(f) *Copper Axe*

Microstructure was dendritic and shows that it was cast. As it contained 1.78% tin, segregation while cooling was expected. Though the central portion was dendritic, near the surface some twinned crystals appeared. This may be due to working.

(g) *Copper Bangle*

Microstructure shows annealing.

6. II. *Typological Considerations*

II. A. TOTAL METAL INVENTORY

Before discussing the typological peculiarities of the tool-repertoires of various cultures, let us assess* the relative abundance of copper. This will help us to draw archaeological inferences in the last chapter.

In general the Pre-Harappan cultures are very poor in metal excepting Mundigak, Nal and Mehi. For example, Nal alone yielded 18 copper artifacts including adzes, chisels and saws. But mostly metal is meagre. No metal was reported from Siah Damb and Anjira. From Damb Sadaat II and III a few copper fragments and a dagger from each period only were recovered. Kot Diji I gave only one bangle and Kalibangan I three objects.

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*. To give metal-inventory of many other sites is not possible, as published reports are not available. Even personal requests did not yield much data. Under the circumstances, the comprehensiveness desired could not be achieved.

The Harappa Culture is undoubtedly richer in copper, as compared to any other culture in question. From the later excavations of Mohenjodaro, from the DK mound (M 37-38) alone, were discovered 14 spearheads, 17 arrow-heads, 18 razors, 23 axes, 53 chisels, 11 fish hooks, 64 knives, an axe-adze and two swords. So also from Chanhudaro (M 43), one mound alone yielded four large hoards containing 16-28 artifacts each. Besides these tools, a very large number of metal vessels of all types, are known from the different Harappan sites.

Such proliferation of metal-working is indicative of urbanisation too. This sudden efflorescence in metal is matched by Uruk Period in Mesopotamia, where too it was accompanied by urbanisation. On the other hand, the other Chalcolithic cultures are relatively less prolific in metal. They never achieved urbanisation. Probably they could not produce the agricultural surplus required for the development of specialised metal-crafts.

The Ahar excavations yielded 4 celts, bangles and a metal sheet. From Navdatoli were recovered chisels, 4 flat celts, 1 shouldered celt, 2 fish hooks, fragments of wire and an unfinished bead. Chandoli gave 2 chisels, 1 celt, 1 dagger, 3 fish hooks, 1 copper rod, 14 beads, 3 bangle pieces, one ring and a broken anklet. In Kayatha were found 2 thick copper celts, several bangles and a chisel. From Nevasa were discovered a chisel, a plate, a rod, a pot, 2 bangles, a poker and 7 beads. From Jorwe are reported 6 flat celts and a bangle. This impressive metal inventory does entitle these cultures to be called Chalcolithic. The slag at Ahar as also crude sand mould casting at Chandoli indicate metallurgical knowhow.

Compared to the Chalcolithic sites, the southern neolithic sites are so poor in copper. For example, Brahmagiri (W 47-48) yielded only one copper chisel and two rods.

II. B. TYPOLOGY

We will now discuss* the characteristics and affinities of the different cultures covered here, as depicted by the typology of the tools. The purpose here is not to give an exhaustive catalogue of artifacts, but to note the significant features only.

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* For this discussion, besides depending upon reports, I examined the collections of Safdarjang Museum, and National Museum, New Delhi; Bharat Kala Bhavan, Varanasi; Municipal Museum and Dr. J. Gupta's Collection, and Kausambi Museum, Allahabad; and State Museum, Patna.

(i) *Pre-Harappan Cultures*

Only Mundigak and Nal provide a reasonable evidence of tools to discuss the typology. From Nal were recovered adzes, saws, chisels and knives. Chisels have a much cruder appearance than the Harappan specimens. Quite unlike the long blade of Mohenjodaro, the Nal axes have rounded or pointed tops. Other types are too general to bear comparison. The socketed axe-adzes are known in Mesopotamia from Uruk times (Ch 57), from Hissar III C, and in Susa from protodynastic period. Nearer home, in Mundigak we have such a shaft-holed axe-adze in Pd III_6. With this evidence the occurrence of such axe-adze even in Harappan levels need not look incongruous and hence need not be associated with later migrations. Though mid-ribbed daggers have been referred to by Lamberg-Karlovsky (L 67) from Mundigak II, yet in the figures given by Casal (Cas 61), who excavated the site, the sections are shown flat. Spiral headed pins from Mundigak II are comparable with the Harappan examples.

(ii) *Harappa Culture*

Some of the Harappan tool-types are very distinctive and can even probably be designated diagnostic of the culture e.g. razors, knives, with curved ends, broad tanged chisels and barbed arrowheads. Beams for balances are also unique.

The razors are of several types, most distinctive being the double edged one. The common types are : double edged razors (e.g. M 37-38, Pl. CXXI, 25-38, 36); L-shaped razors (e.g. M 37-38, Pl. CXVIII, 7); hook-shaped razors (e.g. M 37-38, Pl. CXXV, 39) and; simple blades (e.g. M 37-38, CXIX, 1). Chanhudaro excavations added two more types : U-shaped (e.g. M 43, Pl. LXXIII. 32) and crescent shaped (e. g. M 43, Pl. LXXIII, 31).

The knives too are of different types: triangular and leaf shaped blades with curved ends (M 37-38); plain, leaf shaped, narrow, and straight; and also with curved edges (M 37-38, Pl. CXIX, 8).

Sickle blades are rare : one specimen was reported by Marshall (Mar 31, Pl. CXXXVIII) and another doubtful piece by Mackay (M 37-38). The former had externally sharpened edge; the inside curve was blunt.

The chisels are of different sizes and in very large numbers; from Mohenjodaro alone Marshall (Mar 31) had reported 15 and Mackay 67 (M 37-38) ! They are both long and short with sections varying from rectangular, square to round. The types with broad rectangular sectioned tangs and narrow blades are quite distinctive (M 37-38, Pl. CXIV, 2, 3, 5) of the Harappans.

The spearheads and the arrowheads are very thin. Chanhudaro arrow-heads, for example, were made from sheets of 0.02″ to 0.05″ thickness only. They have backward projecting barbs (M 37-38, Pl. CXXI, 1-5) and are so thin that without the support of a wooden midrib of the shaft, they would buckle. Mackay (M 37-38) thought that such inferior implements could not belong to the Harappans, but to some other conquered people. But they occur from all the levels of Mohenjodaro, Harappa, Chanhudaro, Kalibangan and Lothal and are in fact the characteristic types of the Harappans.

The saws are without teeth and are rare. Only two specimens were reported by Marshall (Mar 31) and two by Mackay (M 37-38) from Mohenjodaro. In one of the specimens the teeth (teeth and the body set alternatively from side to side) are set in the fashion of a true saw, which did not appear elsewhere till the Roman times (M 37-38). The saws are also reported from Harappa, Chanhudaro and Lothal.

The celts or blade-axes were both of long and short varieties. The flat celts are ubiquitous. So also the shouldered examples (M 37-38, Pl. CXIII, 2). These are simple types and occur widely in different cultures. No derivations need be based on such simple types.

The fish hooks too are common in the Harappan sites. They are distinguished by an eye on the top and a barb at the pointed end (IAR 56-57, Pl. XVI; M 37-38, Pl. CXIV, 6), though few are unbarbed too. The ones reported from the Chalcolithic sites, for example, from Chandoli are doubtful specimens. They are just bent rods (DAn 65, fig. 57) without any sharp end, eyes or barbs. I doubt very much if they were really fish hooks. It must be said to the credit of Harappans that their fish hooks were far superior to any produced in ancient Meospotamia or Egypt and indicate the developed art of angling (Hor 54-55).

Coghlan (Cog 54) has described the Harappan tubular drills as the earliest examples in the world. Such drills (M 43, Pl. LXXX) according to Mackay were used for steatite bead making. Whatever the exact purpose, these tools attest to a high degree of skill in metal forging.

The shaft holed axe-adzes are a rarity. They are reported from Chanhudaro (axes only) Jhukar Pd (M 43, Pl. LXXII, 25) and from Mohenjodaro (M 37-38, Pl. CXX 27). Mackay ascribed the latter, despite the 6′ depth, to Kushan Pd. From Mohenjodaro excavations he himself got a terracotta model of a socketed axe (M. 37-38, Pl. CXII, 1) from a depth of 41 feet. We noted above that besides Hissar II, Ubaid Pd in Mesopotamia, such socketed examples (W 66) are also available at Mundigak III$_6$. So both the nearby Mundigak evidence and the Mohenjodaro terracotta example show that the Harappans had the knowledge of the shafthole. Possibly difficulties of casting or conservatism came in the way of its general acceptance. But seeing in such ubiquitous examples evidence for a definite wave of Aryans (Hg 36) looks quite far-fetched.

From Lothal, Mohenjodaro and Harappa several animal figurines depicting dog, swan, birds, elephant (?) and bull are reported. The dancing nude girl figurines reported from Mohenjodaro (Mar 31, XCIV, 6-8; M 37-38) and one from Lothal are fine pieces of craftsmanship. Piggot (Pi 50) saw a Kulli girl in these figurines. The casting technique was probably *cire perdue*.

Four mid-ribbed swords were recovered from the late levels of Mohenjodaro (M 37-38, Pl. CXIII, 3 etc.). They are unique in the Harappan tool repertoire. These swords have a pronounced mid-rib and a thick tang with holes located at the base of the blade or on the tang itself. Wheeler (W 61) has ascribed these types to invaders. But their occurrence in a hoard buried in a small room, as also an unfinished example (M 37-38, Pl. CXXVII, No. 5) militate against such an attribution. Possibly the example from Navdatoli (S 63) may be compared. But Mohenjodaro specimens are much heavier and with a diamond shaped section, whereas the fragmentary Navdatoli piece has a sharply defined oval mid-rib with abrupt flat edges on both the sides.

The sword from Bahadrabad Copper Hoard is nearer to the Harappan types at least in its massiveness and a diamond shaped section. However, instead of holes, here it has a barb. Similar examples are reported from other sites too, e.g., Sarthauli (Lal 51).

Lastly, we should note the reported 'anthropomorph' fragment from Lothal. I have examined a large number of anthropomorphic figures from various collections. Invariably, the Doab anthropomorphs have a thickened 'head' with hammered top which looks like a nail-head in section (Fig. 20). But the Lothal example has a flat section (Fig. 19). Moreover, an accidental break of the arms so near the head in the case of a true anthropomorph, with incurved arms, is not probable. This type of a breakage is more likely if the arms were long and straight, or if the arms were curved

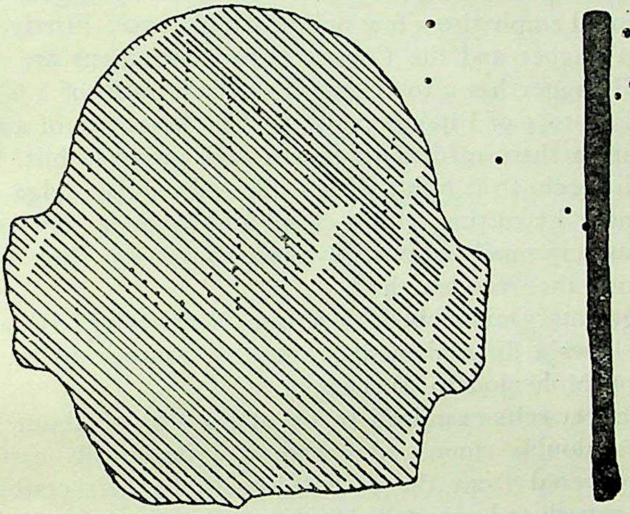

Fig. 19. The so-called "anthropomorph" from Lothal shows a rectangular section unlike the Copper Hoard anthropomorph which has a flattened outer edge (Fig. 20)

in a fashion so as to form a loop for a stirrup-like object. I would therefore hesitate to call it an anthropomorph. An anthropomorph should have a nail-head and sharpened forearms.

(iii) *The Other Chalcolithic Cultures*

We noted above that though the copper inventory of the Chalcolithic cultures is quite large, as compared to the southern neolithic cultures, yet it is insignificant in contrast to that of the Harappans. There are no diagnostic Chalcolithic tool types. The axes are flat and cannot be typologically distinguished from the other cultures. One shouldered celt was found at Navdatoli. The axe from Nevasa (SDA 60, fig. 186, 2) has a peculiar triangular blade, broken at its narrow top. If it were a flat celt, breaking from the edge or from the middle is far more probable than from its thicker and narrow top. It could have broken, in the manner it did, if it were part of a socketed top, or else if it were like the Hallur type (Gu 65a).

The so called fish hooks from the Chalcolithic sites could pass for nails or pins, excepting for one distinctive solitary example

(SSD, 58; fig. 108, 11). Unlike the Harappan examples, they have neither the eye for holding the line, nor a barb.

An antennae hilted dagger from Chandoli (DAn 65, fig. 57, 9) has been compared with similar swords from Fatehgarh (U. P.), etc. I would emphasise a few points of difference. Firstly the former is a dagger and the Copper Hoard specimens are swords. Chandoli dagger has a total length to blade ratio of 1.6 only in comparison to 5 of Fatehgarh sword. The latter are of a massive type, with a sharp median ridge and cast antennae hilt. But the Chandoli specimen is light, with a diffused median ridge and the hilt is made by cutting with a chisel and hammer. The antennae were thus very small and possibly made to prevent slipping of the tang from the wooden haft.

A fragmentary mid-ribbed blade from Navdatoli (S 63), as noted above, shows a diffused median ridge in contrast to the sharp ridges of Mohenjodaro specimens.

The copper celts examined by me at Kayatha of about 1.5 cm. thickness, double sloped edge and of a beautifully cast shape, were recovered from the earliest levels. In their craftmanship they are superb and unequalled in the whole range of protohistory. Also found were a chisel and several bangles.

The other artifacts from the Chalcolithic sites are beads, nails, poker, rods, wires, rings and anklet.

Sankalia noticed a Copper Hoard at Khurdi (Dist. Nagaur, Rajasthan) comprising a flat copper axe, a bar celt, thin curved blades and a channel spouted bowl (IAR 60-61, Pl. LXXVII B). The bowl is analogous to the types found in Navdatoli pottery. These are all unstratified finds, like the rest of the Copper Hoard objects. Out of these artifacts, curved blades could be studied for comparison with the Harappan artifacts, but no illustrations are available. Since spouted bowls are traditionally (even upto modern times) associated with Yajna-rituals, one cannot always assign such hoards any high antiquity.

(iv) *The Copper Hoards*

THE PROBLEM

The Copper Hoards are a polemical problem indeed. There is no end to controversies in the absence of objective stratigraphic evidence; at the moment the conjectures hold the sway. And may be that we have to add a few conjectures of our own—though they would be technologically biased. Below we will discuss the typological affinities and differences of the Copper Hoards with the other cultures. But it may be stated that typological considerations alone have contributed a lot in confounding these issues. We have, for the first time, analysed the artifacts of this group metallographically and spectroscopically. But, it must be admitted, that a much larger number of samples needs to be analysed*, than we could secure, for saying anything conclusively. Though it can now be indicated that the solution of the Copper Hoards problem lies in technological studies, and not in morphological comparisons alone. Even in our typological studies we will put more emphasis on functional and ecological angles.

A large number of copper artifacts were reported from time to time—many of them in hoards, hence the term Copper Hoards. The sites extended from Shalozon in the north west, Bhagrapir in the east, to Kallur (?) in the south. The types too were equally varied : swords; socketed axe and axe-adze; trunnion axe; flat and shouldered celts; harpoons; barcelts; double edged celts; anthropomorphs; antennae swords, spearheads; and rings. About a thousand artifacts have so far been reported. Gungeria alone yielded 424 copper implements weighing 829 pounds ! Thus we see that in the richness of the metal, the Copper Hoards compare fairly well with the Harappa culture.

Piggot (Pi 44) and Heine-Geldern (Hg 36) associated the Copper Hoards with the Aryan immigration into India. Piggot (Pi 50), however, later on associated them with the Harappan refugees. Heine-Geldern's approach is one of the classical examples of pure typological methodology. He (Hg 36) cited comparisons from as widely distributed sites—both in time and space—as Egypt, Sardinia, British Isles, Greece, and Transcaucasia. His conclusions were : (a) the trunnion axe came from Transcaucasia via Persia *ca.* 1200-1000 B. C.; (b) originating from Danubian region the axe-adze also reached via Persia *ca.* 1200-1000 B. C.; (c) the Fort Monroe sword came from West Persia around *ca.* 1200-1000 B. C. and ; (d) the antennae swords were strongly influenced by Koban examples of *ca.* 1200-1000 B. C.

Lal (Lal 51), criticising Heine-Geldern, pointed out that the trunnion axe, the Fort Monroe Sword, the socketed axe-adze and axe never occurred in the Doab [though a socketed example from Kurukshetra is reported (Go 58)]. And the antennae sword, he showed, was cast as a single piece unlike the Koban examples and hence cannot be compared with them. So also, the harpoons, the bar celts, and the anthropomorphs never occured west of the

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* Studies in this line on a long term scale are underway.

Doab. Lal associated the Copper Hoards of the Doab with some pre-Aryan tribal people.

Undeterred by Lal's criticism Heine-Geldern (Hg 56) repeated his earlier formulations. He further found parallels of macehead from Chanhudaro in Hissar III, and noted similarities in the Koban culture of Caucasus, the Gandsha-Karabagh Culture of Transcaucasia, the Luristan Culture and the Sialk Cemetries A and B. He declared that the Aryans, coming from the West, invaded India between 1200-1000 B.C. and destroyed the Harappa civilisation around 1200-1000 B.C.

We would not examine Heine-Geldern's views in detail as they are based, only on single stray finds of a few types, which could be of any date and affiliation. The discoveries of axe-adze from Mohenjodaro (6′ depth), terracotta socketed axe from lower levels of Mohenjodaro, from Mundigak III and Mesopotamia even in the 4th millennium B. C., show the weakness of his arguments. And as far as the end of the Harappans goes, now we know that the end of Mohenjodaro is dated (Chapter III) to *ca.* 2000 B.C.

Gupta (Gu 63) and Lal (Lal 51) have pleaded for an indigenous origin of the Copper Hoards. That seems to me a much more sensible hypothesis than seeking similarities as far as Sardinia and Egypt ! Rich copper ores of Bihar and the wooded plateau seem ideal for early metallurgy—even for independent origins.

Before discussing the individual types, let us examine first the distribution of the main tool types.

In the Doab proper we have three main Copper Hoard types (Fig. 20) viz. harpoons, anthropomorphic figures and antennae swords. I propose two criteria for calling them the three main diagnostic types. First, they have been found together and can be ascribed to the Copper Hoards proper. For example, at Bisauli, anthropomorphs and harpoons occur together; at Bithur harpoons were found with antennae swords; antennae swords and anthropomorphs also are reported together from Fatehgarh. Thus it can safely be concluded that these three types are integral to the Copper Hoard assemblage. Second, typologically they are distinctive types and occur exclusively in the Doab.

The distribution zone of these types is between 78°-84° E. Longitude and north of 24° N. Latitude in the Doab. This zone (we will call it 'Doab Zone') as we will show in Chapter 7, was a thick monsoonal forest and a riverine country, forming a distinct ecological unit which could provide for plenty of game, fresh water fish and limited agriculture. The Copper Hoards with their harpoons, swords, and anthropomorphs truly reflect such a hunting life.

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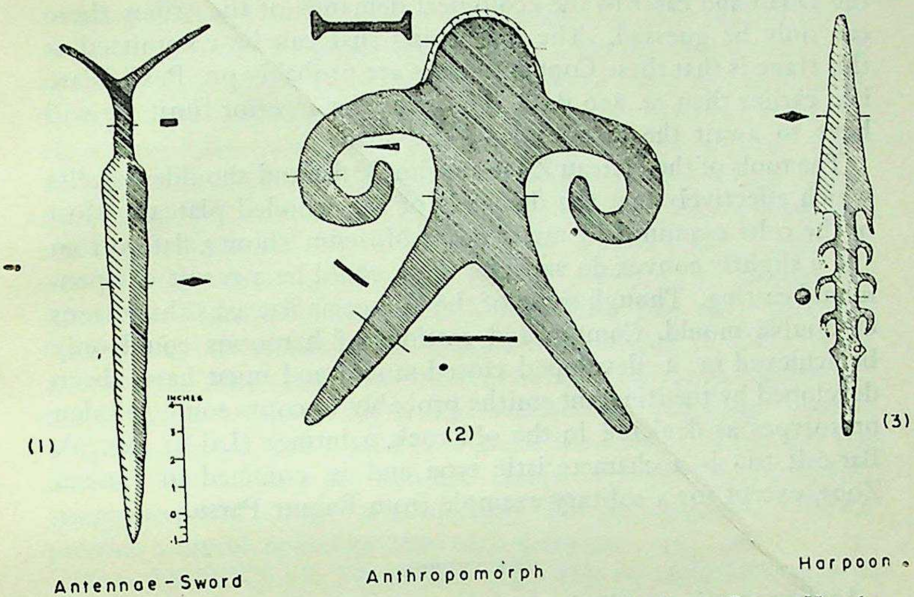

Fig. 20. The three distinctive tool-types of the Doab Zone Copper-Hoards: (1) an antennae sword; (2) an anthropomorph with hammered top and; (3) a harpoon.

I would show below that both the antennae sword and the anthropomorph were specialised hunting tools. It is worth noting that out of about a thousand tools not a single pot or pan of metal has been recovered. That speaks volumes for their uncivilised and semi-nomadic status.

In the south eastern zone, (Plateau Zone) south of 24°N. Latitude, none of the distinctive Doab types are available. In this Zone, we get only flat and shouldered celts, barcelts and double edged axes. The famous site of Gungeria too falls on the plateau extension only. Nearness of Singhbhum copper (e.g., Mauladih, Rakha Mines, Masobani Copper ore sites) must have drawn the attention of the early man in this tribal area. Copper ores are all colourful : chalcopyrite—golden; malachite—green; and azurite—blue. Initial curiosity, accidental discovery and experimentation could lead to independent metallurgical origins. And there was no dearth of wood in the area.

The members of the tribe who mastered this skill must have been economically released of kinship bonds (Ch 57) and became itinerant smiths. They probably were responsiible for forging the distinctive tool-types, suitable for the habitat of the Doab Zone. How much time it took for the Plateau Zone smiths to spread in the Doab and cater to the ecological demands of the tribes there can only be guessed. The only thing that can be committed at this stage is that these Copper Hoards are probably pre-P. G. Ware i.e., earlier than *ca.* 800 B.,C. To define the anterior limit we will have to await the testimony of the spade.

The tools of the Plateau Zone are simple flat and shouldered celts which effectively met the demands of the wooded plateau. Most of the celts examined by me at Patna Museum show a flat bottom and a slightly convex dorsal side. This could be a result of open-mould casting. Though some of the Gungeria flat axes show signs of double mould. Complicated castings of harpoons could only be achieved in a developed closed-mould and must have been developed by the itinerant smiths probably to copy some wooden prototypes as depicted in the old rock paintings (Lal 51, fig. 6). Bar-celt too is a characteristic type and is confined to Plateau Zone, except for a solitary example from Rajpur Parsu.

THE TYPES

I will now discuss the important tool types from functional and ecological angles.

I examined the BARCELTS from Hami at Patna Museum. They have generally a flat or slightly concave ventral side and a convex dorsal side. The edge is produced by bevelling the upper side only. They are quite heavy and long (upto 2′). Several specimens have been reported from Hami and Gungeria. I propose that they were used for mining of the ores; their sturdiness and length (for leverage) would enable their use as a crow-bar too—so essential for mining work. The use-marks observed by me indicate their use against hard surfaces. It is interesting to note that one of the so called barcelts from Gungeria was used as a saw with a serrated edge (Smi 05).

Typological similarity between the stone barcelts and the copper types has led Lal (Lal 51) to think that the latter were derived from the former. It may be pointed out that the sites yielding, stone specimens have not yielded any Copper Hoard artifacts, e.g., Sitabhanji, Ban Ashuria, Santhal Parganas, Jashpur, Thakurani. Dani has compared the eastern stone tools with the south east Asian examples. He proposes, after studying extensively all the south-east Asian stone-tool assemblages, that many of the types e.g., shouldered stone-celt and barcelt have been late derivations from the east e.g., Malaya (Dan 60, Pl. 51, 146 and 152). So in that case stone barcelts are much later than their metal-precursors.

We did not discuss RINGS so far though Lal (Lal 51) had insisted that they formed part of the Copper Hoards. Our difficulty is to determine the criterion for distinguishing these so called rings from the heavy bracelets. There are quite a few examples from the Harappan sites where thick (*ca.* 0.3″ diam.) wires meet their ends (e.g. M 37-38, No. 23-DK 8488) forming a ring. From Jorwe excavations (SD 55) also a thick ring (bracelet ?) with 12 mm diameter was reported. From Bargaon, an allegedly late Harappan site in Dist. Saharanpur, too a ring is reported by Deshpande (Des 65). Thinner bracelets are ubiquitous. The only criterion for the ring characterising the Copper Hoards could be their standard weight. They could be convenient units of metal-weight for the itinerant smiths to carry. The number of such rings expended in making a tool would be a useful measure to determine the barter. But till they are weighed and a correlation found this suggestion will remain a conjecture. The 47 rings from Pondi provide a useful collection for such a study.

The ANTENNAE SWORDS (Fig. 20), so called because of their antennae like bifurcations of the hilt-end, are confined to the Doab Zone (with the solitary exception of the distant Kallur*, in Raichur Distt.). While discussing the Chalcolithic cultures' tool repertoire we noted the technological differences between the Chandoli antennae-hilted dagger and the antennae swords. We may recall that the Chandoli dagger was cast as an ordinary tanged dagger, then the end of the tang was split by a chisel and bent a little to form the incipient antennae. The Doab swords are, on the other hand, cast with the antennae as one piece and have long blades with a short hilt (here total length to blade ratio is about 5; whereas in Chandoli it is only 1.6). Their length ranges from 42-75 cm. (Smi 05). Further, unlike the diffused ridge of Chandoli, the Doab examples have a sharp median ridge. The Doab specimens are massive; the Chandoli dagger is flimsy in comparison.

I considered the possible functions of the antennae sword, because the antennae are a definite handicap in its use as a weapon of warfare. But their developed nature (each antenna is more than 4″) does indicate some functional use. I suggest that the antennae swords were used for killing or wounding big game by trapping.

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* It may be noted that the three swords from Kallur though have the antennae yet they are just about 1″ long in contrast to more than 4″ long ones of the Copper Hoards. There are many other differences too. Besides, the excavations nearby yielded copper ore, iron ore and even an Andhra coin (AR 38-39) suggesting a historical date for the swords.

The advantage of antennae hilt will be that the swords can be fixed securely in narrow clefts made in heavy wooden logs. Such logs, with antennae swords projecting out, could be placed in the bottom of big pits. The pits could be camouflaged with leaves and twigs and big game would be stampeded towards the pits. The game would fall heavily on the projecting swords which would pierce it through without getting buckled or sunk in the ground with the weight. A straight hilt or tang will be buried into the ground under the heavy impact. The use suggested here is conjectural but appears quite probable in the context.

The type referred to here as the ANTHROPOMORPH (Fig. 20) is generally termed as 'anthropomorphic figure' in the archaeological literature. And, as is our habit, any object the use of which is not clear, is labelled a ritualistic object ! In this case the human like shape of the object easily lent itself to such an explanation. I had the occasion of examining several anthropomorphs in various museums. Its three important features (Fig. 20) are : a hammered and blunted head, externally sharpened and incurved forearms, and plain legs. The shape is cut from a plain copper sheet and, by beating, the arms are made thinner than the head. The head is further thickned by beating from the top (see the section in Fig. 20). To determine its function I made an imitation-model and tried it as a missile. It goes in a whirling fashion. It is forged in such a way that if it is thrown at, say, a flying bird it can bring down the bird in any of the three ways : the sharp forearms will produce a cut; the heavy head will stun the prey; and if the prey is caught in the curved arm the whirling motion will entangle it and bring it down with the missile. I think the thickening of the head (manipulation of the centre of gravity) helps its whirling motion, and may impart some boomerang like property. Recently Felix (Hess 68), who has been working on the aerodynamics of boomerangs, says that the shape has hardly anything to do with the return of a boomerang. "The essential thing is the cross-section of the arms, which should be more convex on one side than on the other." The almost triangular sections of the arms of the anthropomorph seem to answer to this requirement. In whatever way it was used*, there cannot be any reasonable doubt about its use as a missile. I think the invariably sharpened forearms, the blunted heavy head and the plain legs to hold it while hurling conclusively prove its use as a missile.

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* No museum allows to take the objects to labs. for proper study and measurements; hence the boomerang effect could not be verified.

As noted before, the so called anthropomorph from Lothal appears very much different from the Doab specimens. The hammered head feature is absent in Lothal; it is plain in section (Fig. 19).

The HARPOON is like a mid-ribbed spearhead with oblique or backward curving barbs; quite often with a hole on a lug. They are of two types : first, cut and hammered from a thick sheet; second, cast in a double mould. The first type looked so primitive and crude in comparison to the second. Stratigraphic evidence alone can decide if the cut-type is really a precursor of the cast-variety. The latter is a superb example of their craftmanship and shows that the Copper Hoard-smiths had solved the problems of closed casting of pure copper. These harpoons could be used as spearheads for big game as shown by Cockburn (in Lal 51) or as harpoons for killing large fish.

Thus we see that the three artifacts, namely, the harpoon, the antennae sword and the anthropomorph, are type-tools of the Doab Zone and are not found in any other culture. Let us now study the other important types.

Lal (Lal 51) emphasised that the shouldered CELTS were not available in Harappa Culture. But I think the available evidence suggests that there is no qualitative difference between the flat and shouldered types; between the sharply kinked shouldered examples and the flat ones there are all grades and degrees of shoulder. Some Harappan examples can only be described as shouldered (*e.g.* Pl. CXIII, 2, M 37-38; Pl. V, Gu 65a). I hold that both flat and shouldered varieties are too simple and ubiquitous tools to be of any diagnostic value for any culture.

Ten DOUBLE AXES are reported from Bhagrapir (Orissa), and this is the only site which has yielded this type (Gu 65a, Pl. II). They are made by cutting away almost circular pieces from the sides of an oval sheet, thus imparting it a distinctive shape. The three specimens measured $18\frac{1}{2}'' \times 15\frac{3}{4}''$, $10'' \times 8\frac{1}{2}''$ and $10\frac{1}{2}'' \times 7''$ with thicknesses varying from 1/20″ to 1/8″ (Gu 65a). Two of these had both the edges sharpened and the third, only one edge. Such thin tools with such a big body would buckle the moment they are used as axes. In fact, calling them axes is a complete misnomer. They might even have been meant for historical land grants (Go 58).

The oblong celt from Lothal, the edgeless double 'axe' (?) from Harappa, and the triangular bladed axe from Hallur all look connected to the double axe according to some scholars (Gu 65a). Even morphologically all these examples are types by themselves and do not allow any comparison. If we divorce the tools from the use they were put to, typological consideration alone makes us lump the Copper Hoards, the Harappans and the Neolithic people together. The Bhagrapir double axes are unassociated with any Copper Hoard type and could be of any date.

The hooked SWORDS were found associated with our three diagnostic Doab types as evidenced at Fatehgarh, Niori, Sarthauli and Bahadrabad. At Mohenjodaro too we got four mid-ribbed swords with holes on the blade or the tang (M 37-38, Pl. CXIII, 3), though without a barb. The Navdatoli fragment of mid-ribbed blade too was discussed above and the differences noted. The Copper Hoard swords or spearheads have a barb near the end of the tang. The barb (for hafting) was not cast originally but has been chiselled off from the tang itself. The median ridge is quite sharp, unlike the diffused ridge of the Navdatoli fragmentary blade. The type however is a general weapon of thrust and is not of much comparative value to trace contacts.

A solitary PARASU or hatchet is reported from Sarthauli. It has been found with the cut-variety of harpoon.

Also worth noting are the thin flat, long blades from Bahadrabad which, I found, have sharp edges on one side and the tip. Did they serve as sickles ?

To summarise, we have not attached any importance to the stray single types. We noted how the theories based on such stray finds and a purely typological approach can lead one to very far-fetched conclusions. Distinguishing two main areas—the Doab Zone and the Plateau Zone—we defined their main tool types. The Doab Zone is marked by the harpoon, the antennae sword and the anthropomorph. We showed their utility in a hunting nomadic life. We also noted the absence of any pots and pans in the whole range of the Copper Hoard repertoire. The Plateau Zone has only a bar-celt as a distinctive feature. Celts of all varieties are ubiquitous. The total metal in the Copper Hoards is quite sizable and compares well with the Harappan. The harpoon is a masterpiece of closed pure copper-casting.

The alleged parallels in certain tool types between the Copper Hoards and the other cultures are superficial only and do not bear closer scrutiny. The Copper Hoards are unique and probably isolated phenomenon in our prehistory. And probably they represent the original inhabitants of the tangled, wooded country of the Doab, before the P. G. Ware people started clearing the forests with their iron tools. Chota Nagpur Plateau, with its rich copper ores and plenty of wood, could have independent origins of metallurgy—even in the late second millennium B. C. The ecological barrier of the primeval forests of the Doab could have isolated the authors of the Copper Hoards effectively from the west.

Here it is relevant to note that the eastern India had contacts with the south-east Asia in the late neolithic times (Dan 60; Wor 49). Latest research in Thailand (Sol 67) shows that the copper technology there starts in *ca* .2300 B. C. as indicated by the C^{14} dates for Non Nok Tha Site: TF-651, 2325±200 B. C. (dated by us) and GaK-956, 2290±90 B. C. for layer 19 bearing copper-axes and moulds. This also suggests the probability of the Copper Hoards having a South-east Asian inspiration. In the present state of research nothing more can be committed: either the Copper Hoards are inspired by the east or have independent origins.

The Copper Hoards have not been found in association with any pottery so far, though circumstantially they have been associated with the O. C. Ware. The identity of the O. C. Ware itself is doubted. Sharma (Sha 65) has identified the O. C. Ware with the late Harappans and attributed Copper Hoards too to them. Deshpande (Des 65) has claimed Harappan affinities for the Baragaon O. C. Ware. Though in the light of Wheeler's diagnostic features (Chapter 2)it is still a doubtful case. Deshpande has noticed (Des 65) there Cemetery-H strain also. Gupta (Gu 65) has rightly pointed out that the O. C. Ware has an individual identity and is non-Harappan. Above, we have tried to establish the individuality of the Copper Hoards beyond any doubt. In this light an indigenous tribal origin looks more probable. Gupta and Lal identified them with the 'Mundas'. "The Hoard people might have been the 'Mundas' who once expanded from Bihar to Garhwal and then again retreated. The presence of 'Munda' speech amongst Pahari group of languages and the proto-Austroloid people in Doms, Koltas, etc. in the Indo-Aryan population of the cis-Himalayan region amply testifies to this story of migration and return. Grierson and Risley also have supported this theory". I may add that even today smithy is exclusively a Dom occupation in Kumaon. It may be noted here that the eastern Australenesian tribes (forefathers of Monkhmers, linguistically affiliated with the Mundas) independently passed on to the use of metal. And north-east India has been considered an integral part of South-east Asia in the Neolithic period (BD 57). As mentioned above, in view of the early dates of the metal-age in Thailand (Sol 67) the probability of a diffusion of the metal technology of the Copper Hoards from the east becomes strong.

6. III. *Conclusions*

Before drawing the conclusions let me summarise the evidence adduced above.

The Pre-Harappans were very poor in metal. The evidence only indicates that copper was being used on a small scale either because of lack of known local ores or due to the inability of the Pre-Harappan societies to afford full-time metallurgists. We do not have enough data to derive typological correlations.

The Harappans, on the other hand, show a sudden upsurge in metallurgical activity. They have a profusion and variety of pots and pans indicating the knowledge of the techniques of 'sinking', 'raising', 'running on' etc. But no metal vessels are reported either from the Chalcolithic cultures, or the Copper Hoards. The Harappan and the Chalcolithic artifacts betray the knowledge of cold working and annealing also, which were probably not known to the Copper Hoards people. Quite developed casting methods, including *cire-perdue*, were used by the Harappans. However, open-moulds were quite often used. The Chalcolithic people probably used only open moulds. But the Copper Hoards show the use of closed-casting as indicated by the harpoons and the tell-tale ridges on some Gungeria axes. Closed-casting of pure copper is a difficult thing indeed to achieve; perhaps the lack of tin or the know-how precluded alloying in the Copper Hoards. In the metal forging technology the Harappans are the most advanced, then come the Copper Hoards, and lastly the other Chalcolithic cultures. Alloying was practised both in the Harappan and the Chalcolithic cultures, but probably not by the Copper Hoard-people.

The Harappans have very distinctive types: the razors; the arrowhead; the barbed fish hooks; and the curved blade. They even had the first true saw and the first tubular drills which show their ingenuity. The Copper Hoards are distinguished by the anthropomorph, the antennae sword and the harpoon—so well adapted for a hunting nomadic life. The Chalcolithic cultures, however, have very simple types which are ubiquitous. In the metal repertoire there is nothing very characteristic of them. The typology shows that the Harappans, the Chalcolithic cultures and the Copper Hoards are distinct groups without any demonstrable affinities. The alleged links—like the Chandoli antennae dagger, the Lothal 'anthropomorph'—were shown to be technologically much different than their so-called counterparts in the other cultures.

Amongst the Chalcolithic cultures, the Banasians are distinguished by the lack of microliths and presence of definite metallurgical evidence; the Malwa by the use of 'microliths' and; the Jorwe by the use of ground stone axes. The evidence is too meagre for finer distinctions.

Finally, in the total metal inventory we saw that the Harappans led the rest in the abundance of metal, followed by the Copper Hoards. The other Chalcolithic cultures are poorer in this comparison too; but are far richer than the neolithic cultures of the south.

The considerations of space, time, typology and technology, all go against any possibility of links between these three disparate cultures. We showed earlier (Chapter 3) that the Chalcolithic cultures succeed the Harappan. The Copper Hoards may be later still. The three groups have distinct geographical distributions (Chapter 2) and, in fact, thrived in different ecological zones (Chapter 7).

The richness of the Harappans in the metal is due to the agricultural surplus and the discovery of local mines: both the things are inter-dependent. A society without a fluid surplus can not support metallurgical specialists. The large number of the so-called narrow axes and chisels could have been used as hoes. In the pliable fertile Indus plains, simple copper tools and even big chert blades could help cultivation. There are several chert blades, smoothed all over (Chapter 2), which could also have been used as hoes mounted on sticks. An efficient village economy with agricultural surplus, with metal-technology, abundant source of metal and an optimum ecology (Chapter 7) could burst fast into urbanisation—as it probably did in the Indus.

The Copper Hoards people too have a developed tool technology and abundant metal. Their individuality and isolation may indicate even independent origins of their metallurgy, though late. The wooded plateau and rich ores were ideal for such a discovery. But the ecology was not suitable for the growth of urbanisation in the Doab. The thick monsoonal forests were rich in game and the rivers full of fish. Their tool kit, of the antennae sword, the anthropomorph and the harpoon, was ideally suited for a hunting nomadic life (Chapter 7 and 8). However, this metal-technology does not indicate the presence of specialised craftsmen in the society but only itinerant smiths who were probably released from the kinship bonds. Complete absence of metal pots and pans, despite abundance of the metal, does prove a nomadic existence. No permanent settlement mounds of the Copper Hoard culture have so far been identified—nor are likely to be. To colonise the Doab only the iron-technology and abundance of iron were the answer.

For the real superiority of iron over copper does not lie in its strength but in its abundance.

The Chalcolithic cultures probably were handicapped both by ecological factors (Chapter 7) and scarcity of the ores. The narrow alluvial strips could not produce enough surplus to develop metal-technology nor could they help usher them into urbanisation.

We will discuss the role of ecology in greater detail in the next chapter and synthesise all the evidence in the last chapter.

CHAPTER 7

ECOLOGY

In chapter 3 we had defined the settings of different cultures in time. Now we will outline this setting in space i.e., the ecological settings. In Chapters 5 and 6 we tried to determine the technological status of the various proto-historic cultures, but to assess the role of technology in a particular culture we have to take into account the ecology. Because "the study of early human societies can not be confined to the cultural equipment of the people concerned. They lived in a world which provided them, as ours provides us, with food, clothing, shelter and common materials only in exchange for intelligent appreciation of natural resources and much hard work in exploiting them" (Co 64). To reconstruct their ways of life we have to take into account the natural setting in which they had their being. It has been said that "no major activity of human society is independent of the (ecology's) helps, hinderences or directives" (Whi 48). Even the national integration of our country is affected by geographical factors. The east-west flowing rivers have caused a horizontal partitioning of the country thus creating physical barriers against free mixing of the north and the south throughout history. The presence of the Himalayas, on the other hand, has isolated the country from the continent, creating a sense of contempt for the foreigner and a false sense of security (Pan 63). In the period we are interested, the ecological factors affected the human societies in an even more significant way.

It may however be emphasised that the environment or ecology alone does not determine man's destiny. The development of technology made it possible for the man to wrest himself free from the determining effects of the environment. The role of geographical factors in the development and patterns of Indian cultures has been discussed by various scholars (Ri 32; Pan 55; Pit 59; Sp 63). But it was Kosambi (Ko 63) who first emphasised the role of technology in a given ecology. Subbarao (Su 58) too, tried to define the personality of India on the basis of the ecological factors. He (Su 58) recognised three types of regions : the perennial nuclear regions which were areas of attraction; the *culls-de-sac* or areas of isolation and; the areas of relative isolation. For example, he included Malwa, Panjab, the Gangetic basin and the Deccan plateau in nuclear regions; Sind and Gujarat in the areas of relative isolation and; the wooded plateau of Chota Nagpur, Vindhyas and Arawalli ranges in the *culls-de-sac* (Su 58, figure 6).

In 1958 it was a brilliant synthesis of the available data. But Wheeler in his foreword to Subbarao's book (Su 58) itself had predicted, "A dozen years hence it will have to be rewritten, preferably by Dr. Subbarao himself". Unfortunately Subbarao is no more and other archaeologists have not paid so much integrated attention to the ecological factors.

In the present chapter I will try to determine, on the basis of the recent data, the ecologies of the various protohistoric cultures. I will begin with a review of Subbarao's 'regions'.

Though Subbarao himself had recognised a fine correlation between the optimal rainfall zone and the areas cleared for cultivation, yet, he could not assess the role of man in changing the ecology. For example, the Gangetic basin is a perennial nuclear region in his scheme but, as I will show later, this area was a dense monsoon-fed forest and hence not so attractive to the early man. The Doab became attractive only with the development of iron technology and mass abundance of iron-tools which enabled the large-scale clearance of these wooded plains for settled agriculture. The Doab was as inhospitable to the copper-age man for settled agriculture, as the wooded plateaux were. Subbarao had included Sind in the area of relative isolation, despite the great Indus flowing through it. It was the area where the Harappan civilisation flourished. In fact, all the earliest civilisations developed in similar milieus. The Nile, the Tigris-Euphrates and the Indus all watered semi-arid regions bringing fertile silts with the floods each year. In such valleys large-scale agriculture, and hence agricultural surplus, was easy to produce provided the man-power and enough tools were available. Nor the Narmada basin could really be called an area of attraction. It is such a narrow valley with wooded uplands on both the sides that no large-scale agricultural settlements were feasible there.

In my approach, I will first try to reconstruct the original ecology available to the protohistoric cultures. I shall then evaluate the interaction of technology and ecology in the genesis of civilisation. However, for the vegetational reconstruction the data are meagre at present. Only recently some palaeo-botanists (V 67-68; Sin 63) have started studying the ancient vegetation in

Kashmir, Sambhar lake area and Panjab. The ecological patterns will be discussed in the following order:

I. The Indo-Iranian border lands;
II. Sind, Panjab and Rajasthan;
III. The Doab; and
IV. The Central Tableland.

7. I. *The Indo-Iranian Border Lands*

While describing the Pre-Harappan cultures (Chapter 2) we had briefly noted the geological setting of the north-west. Afghanistan and Baluchistan are similar in physiography; the former having the higher mountain ranges of Hindukush also. The inhabitants maintain a rather precarious semi-arid agricultural and herding economy. Human occupation is confined to the eastern and northern valleys; the arid climate and the isolating effect of the mountains give rise to deserts. In the Quetta-Pishin area, in these valleys the water supply just suffices to grow the essential commodities. The north-south trend of the mountains aids in funneling the winds from western Central Asia into the valley. The south and east winds are blocked by the southern mountains. As a result the climate is more like eastern Iran than that of Sind and Panjab. Baluchistan as a whole is west of monsoonal rain shadow; it has less than 10'' of rainfall. The rainy season is reverse of that in India, with heavy winter rains caused by cold air storms from the Mediterranean.

The flood plains are confined to small areas because of high bluffs of the riverbeds and the intermittent nature of the streams. Riverine irrigation is more common in the uplands. Wells are in use. Dry farming (*khuskab*) is also commonly employed (Fa 56). The narrow basins of this region, with the intervening mountain barriers, impeded contact and communication resulting in a plethora of disparate cultures. This multiplicity of cultures is ecology-based. On the other hand, the uniform ecological zone of the Harappa culture was to a large extent responsible for its uniformity.

The hypothesis of progressive dessication proposed by Stein (Ste 31) was primarily based on the discovery of gabarbands (dams) and a larger number of ancient mounds compared to the present settlements. These suggested to Stein moister conditions in the past. However, his arguments have been effectively countered by Raikes and Dyson (RD 61; R 67) and Fairservis (Fa 56, 61).

Fairservis (Fa 56) has pointed out that the ancient "sites occur everywhere in the valley where fertile soil and water exist today, indicating that climatic conditions and the ecology of the modern Quetta valley are comparable to those of prehistoric times."

Moreover, Stein did not take into account the transhumance that is a usual feature of life in these areas today. Unless they have both perennial water and mild winters, to survive, they have to migrate seasonally. It is quite likely that many contemporary sites are due to the same people as a result of transhumance. Dependence on *khuskab* (dry farming) may too have necessitated migrations. Thus the harshness of nature itself may account for a multiplicity of sites of which, at any time, only a fraction could have been occupied.

The large number of gabarbands, quite often built of massive stones, in Baluchistan, had suggested to Stein the use of greater man-power and plenty of water to store in. Raikes (R 67) has shown that a block of stone 60 × 100 × 150 cms. in size will weigh 2 tons; to carry it about sixty men will be required. How can 60 men hold only 1 cubic metre stone. Obviously leavers were used; the use of such stones shows skill rather than man-power. He has further proved that they were not dams, as they do not fulfil even a single criterion of a dam. He holds that the gabarbands were terraces to trap cultivable soil. "Terraces of this particular kind, depending on occasional spates in otherwise dry torrent beds or on local run-off from bare hill sides, are essentially and everywhere an arid-zone phenomenon" (R 67).

Thus we see that the climate was not drier in the past in this area. The peculiar ecology was responsible for the multiplicity of cultures, as also for the lack of large-scale settlements. It is interesting to note that both polychrome and bichrome traditions occurred together in Mundigak III (Chapter 2). Later on they split. The Nal people with the polychrome tradition started practising a mixed farming and animal husbandry in the uplands. But those who descended down to the foothills and the Indus plain area, e.g. the Amrians, with the bichrome tradition, eventually contributed to the Indus urbanisation.

7. II. *Sind, Panjab and Rajasthan*

Any study of the Harappa culture, its genesis and development, and its 'explosive evolution', has to take into account, the milieu in which it thrived. An understanding of the ecological factors is essential to unravel the mystery of the Harappan urbanisation.

For it is the ecology which offers the opportunities for growth, as also imposes the limits.

But the ecology of the Harappan period is a subject of serious polemics. So, first I will discuss the older views and then take up their criticisms in recent times. I will examine various theories critically and try to derive my own conclusions. Finally I will evaluate the role of ecology in the making, as also the unmaking, of the Harappa culture.

Stein, as noted before, found a large number of gabarbands in Mashkai, Jhalawan, Sarawan etc. He concluded that these gabar-

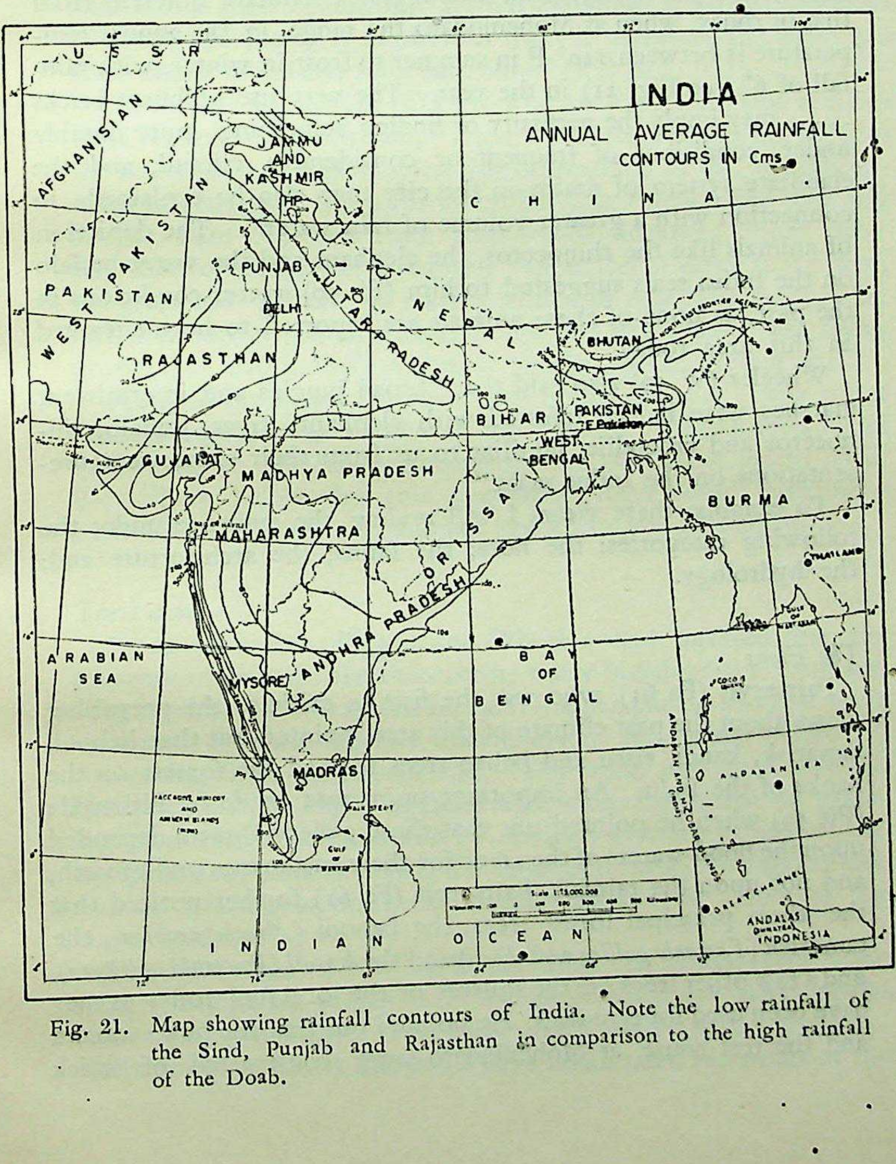
INDIA
ANNUAL AVERAGE RAINFALL
CONTOURS IN Cms
U S S R
AFGHANISTAN
WEST PAKISTAN
PAKISTAN
JAMMU AND KASHMIR
HP
PUNJAB
DELHI
UTTAR PRADESH
NEPAL
CHINA
RAJASTHAN
BHUTAN
NORTH EAST FRONTIER AGENCY
BIHAR
PAKISTAN
E Pakistan
WEST BENGAL
GUJARAT
MADHYA PRADESH
BURMA
MAHARASHTRA
ORISSA
ANDHRA PRADESH
THAILAND
ARABIAN SEA
MYSORE
BAY OF BENGAL
MADRAS
ANDAMAN SEA
ANDAMAN AND NICOBAR ISLANDS
GREAT CHANNEL
ANDALAS
INDONESIA
INDIAN OCEAN

Fig. 21. Map showing rainfall contours of India. Note the low rainfall of the Sind, Punjab and Rajasthan in comparison to the high rainfall of the Doab.

bands (embankments) "manifestly go back to an early period when climatic conditions were more favourable and the tract could support a much larger population" (Ste 31). The occurrence of a large number of gabarbands, the extensive ancient remains, and the large mounds indicating cultural stability, had suggested to Stein a progressive dessication in that area.

Piggot and Wheeler extended the progressive dessication hypothesis to Sind also. Piggot (Pi 50) summed up the relevant data in these words, ". . . the inference from the fauna, the wood needed to burn so many million bricks, and the implication of a flourishing agricultural background, all suggest a climate different from that of today, when at Mohenjodaro the range in the annual temperature is between 120° F in summer to frost in winter, with rainfall of 6" (see Fig. 21) in the year. The very use of burnt bricks . . . . . may imply the necessity of finding something more durable under conditions of frequent or considerable rainfall, and the elaborate system of drains in the city may also be explained in connection with a greater volume of rain water". The depiction of animals like the rhinoceros, the elephant and the water buffalo on the Indus seals suggested to him (Pi 50) wetter conditions in the past, as none of these animals are reported to have survived in this area today.

Wheeler (W 59) also said that "broad jungles and intermittent marshes were indeed infested with elephant, tiger, buffalo, rhinoceros and crocodile, familiar to us from their exquisite representations on the Indus seals."

To examine these views I will review the evidence under the following categories: the flora; the fauna; the architecture and; the hydrology.

The Flora

Fairservis (Fa 61), who was the first to criticise the prevailing views about the past climate of this area, pointed out that babool, tamarisk, kandi, sissu and behan trees formed the forests on the banks of the Indus. An important point was made by Pithawala (Pit 59) when he pointed out that these gallery forests depended upon the flood-waters of the river for their sustenance and growth, and not upon the rainfall. Fairservis (Fa 61) further noticed that the three principal forest trees, the babool (*Acacia arabica*), the tamarisk (*Tamario gallica* and *dioca*) and the kandi (*Prosopic spicigera*), and a few other trees are the sources of the local fuel today as they have been used for centuries. He pointed out that the new museum and the rest-house at Mohenjodaro were constructed of "brick made of local clays and fired harder than the Harappan bricks by kandi wood fuel". This wood grows abundantly and produces a hot fire at a relatively low rate of fuel usage. Raikes and Dyson (RD 61) also hold that the local wood was used for making bricks as it is being used today. In fact, even upto 1908, wood was exported from this area. They have also calculated the amount of wood required for the bricks used in Mohenjodaro. "A rough, but very liberal calculation indicates that the fuel for each re-building of the city could, in fact, have been obtained from about 400 acres of gallery forest assuming that each re-building was done in one short operation. With re-buildings at average intervals of about 140 years, it is obvious that if necessary the same 400 acres could have been used each time" (RD 61).

Chowdhury and Ghosh (CG 51) who analysed the plant remains from Harappa explicitly said, "These wood remains do not support the theory that a moist tropical forest prevailed in the neighbourhood of Harappa. Even for house building timbers like pine and deodar were obtained from considerable distances. From these and other evidences we visualise a vegetation of scrub forest with tall grass and pockets of marshy land at or near Harappa." The fact that cotton, which thrives in hot and dry climate was being grown may also indicate a climate similar to the present day.

The evidence quoted above clearly points out that : there is not much change in vegetation and; the riverine gallery forests could easily cater to the fuel requirements for the burnt bricks used. We will see below that this vegetation itself could have been a natural habitat for the animals known to the Harappans.

The Fauna

As noted before, Piggot and Wheeler had inferred that the presence of animals like rhinoceros, water-buffalo, tiger, elephant, suggested wetter conditions in the Harappan period and that their extinction now was due to a drier climate. But Fairservis (Fa 61) countering these arguments said, "The fauna associated with the Harappan civilisation is, without exception, dependent on grass-land and open forest country. . . . .(which were the habitat of the big game and, coincidentally, the areas best suited for agriculture and the grazing of domestic animals spelled the doom of the larger wild life".

The tiger is known from the Upper Sind. Its habitat is the dense fringe of tamarisk bushes and long grass along the banks of the river which provides its three basic needs—water, shade, and prey. The rhinoceros too is known to have inhabitated the banks of the

Indus just 300 years ago. It prefers to live in heavy grass-jungle and marsh along the river. So also the water-buffalo which likes a habitat of thick and high grass-jungle or reeds, but rarely enters a tree forest. Mongoose, which is attested to from the excavated remains, likes a similar habitat, or cultivated fields but never a dense forest. Land snails are quite sensitive to moisture and the only identified snail from Mohenjodaro is *Zootecus insularis*—a native of arid regions. Of course, the elephant was never found west of the Madhya Pradesh and therefore could have been an import in the Sind (RD 61).

Thus we see that the biological evidence too indicates a similarity between the past and present climates. For the extinction of the wild life, man is responsible and not the climate.

The Architecture

Under this heading will be reviewed the structural evidence which has been quoted in favour of a change in climate.

The elaborate drainage system of the Harappan cities was allegedly meant for draining out the excessive rainwater in the presumed wetter conditions of that period (Pi 50). Raikes and Dyson (RD 61) however made some rough calculations of the run-off capacity of the Mohenjodaro drainage system and showed that it was not adequate to carry off the storm water from an average present day short period storm even.

However, I feel that their arguments on this point are not tenable even if we grant that their calculations are reliable. Firstly, they assume that the high annual totals reflect a greater number of storms. There is no evidence to prove it for the Harappan period. Secondly, even efficient drainage systems fail under heavy storm showers. A normal drainage—even for normal rainfall run off—may not necessarily be equipped to cope with occasional heavy storm spells.

The use of burnt bricks too has been adduced as an evidence for a wetter climate, but is not warranted. Firstly, sun-dried bricks have been used in the Harappan cites—sometimes in alternate layers with the burnt ones. Secondly, in many buildings *sundried bricks alone were* used. Thirdly, even the burnt brick buildings were covered with sun-dried mud-plaster. However, the use of burnt bricks in making important structures, like granaries, flood-proof stands to reason. It has been pointed out that even in areas with 20" rainfall—five times that of the present Sind—mud bricks are used. At least, it is clear from the above that the use of burnt bricks can not be used as a climatic evidence.

To summarise, we noted that the faunal, the floral and the other data show that there has been no drastic change in the climate of the Sind-Panjab area since the Harappan times. Wheeler (W 59) had suggested that excessive forest-clearance may have worn out the landscape which led finally to the end of the Harappans. But we have seen that there were no monsoonal-forests and the gallery forests extant then must have sufficed their needs for brick-kilns without 'wearing out the landscape'. Wheeler (W 66), receptive as he is to new ideas, now says, instead, "Mohenjodaro was being steadily worn out by its landscape".

So we can not accuse the climate of bringing about the downfall of the Harappans. In fact, as we will see later, the ambient ecology provided the optimum conditions for the Harappan urbanisation. But did nature conspire in other ways for the degeneration of the Harappan society? This will be discussed below under hydrology.

The Hydrology

When Sahni (Sa 56) suggested that an impounding of the Indus could be responsible for the end of Mohenjodaro, nobody took him seriously. Now Raikes (R 65) has forcefully revived the same hypothesis and the archaeologists are greatly excited over it. Raikes got involved in these probems while working in Baluchistan in connection with his hydrological studies. He found—in the course of his field work—that the theories of progressive dessication, referred to above, were not tenable at all. Here I will discuss his positive suggestions regarding the probable causes of the end of Mohenjodaro. For a while his theories held sway; only now some dissenting voices are being raised. And some of the objections raised are serious indeed. I will have to go into the details of the controversies as the issues involved are crucial for our contentions too.

Raikes (R 64) started by expressing his doubts about the millennium long spread of the Harappa culture (Chapter 3). He was already studying the flood evidence at Mohenjodaro and thought that probably the end could be due to some sudden catastrophe like the impounding of the Indus, as originally suggested by Sahni (Sa 56).

Dales (D 62) had also noted that tectonic uplifts were probable on the Makran coast as he found that Sotka Koh and Sutkagen Dor originally ports—were now several miles in land. In the southern part of the Indus plain—from Amri and Chanudaro to the mouth of the river—no Harappan sites could be located despite an intensive search. Raikes suspected these parts to be under the sea in the Harappan times. However, I may point out here that the probable submerged area as shown by him (R 64, fig. 1) could not have been under the sea on the Indian side at least. Joshi has explored several Harappan sites in the northern Kutch (J 66).

Several raised beaches were observed in aerial photographs of the Makran coast—though their ages were not known. Now Asrar Ullah (in R 64) has equated some of the raised beaches with terraces in the inland valleys. Since none of the terraces has completed an erosion cycle, he infers a short period for them. Raikes even suggests that the end of Nindovari may have been due to the cutting off of its water supply by a tectonic uplift. In the beginning he (R 64) was emphasising on the uplifts and the consequent earthquakes for the destruction of the Harappan cities. But later he (R 65) built up a theory where floods wrought the main havoc; of course the ultimate cause was tectonic activity.

Raikes and Dales (R 65) studied the flood problem in Mohenjodaro in greater detail in 1964-65. They found "both water deposited material and mud-brick filling (to) occur at various levels upto about 29 ft. above the flood plain." They drilled three exploratory boreholes (in HR area and midway between HR and Citadel areas). In the HR area they found "silty clay with irregular occurrence of occupation debris down to 38 ft. below the flood-plain; between HR and the citadel encountered the same material to 50 ft. below the flood plain". They further studied the areas around Lake Manchar, Jhukar and Amri too.

In their analyses of the flood deposits they could not find the existence of general inundation levels as suggested in Piggot's stratigraphy. "A graphical plot of the 150 cases studied and of some additional occurrences resulting from the new excavations show that there are only three zones, between +155.5 and +158.5, +168.5 and +170, and +175.2 and +176.7 where intervals of 1.5 ft. or more contain no flood levels" (R 65). There was nothing in the evidence they could find which went against their original assumption that the flood deposits are of still-water origin and that these conditions were caused by the impounding of the Indus water by uplift.

For their studies they assumed that the mean annual flow of the Indus in the Harappan times was about the same as today viz. about 160 million acre ft.* The present silt load of the river was taken—on the basis of meagre data only—to be more than 1%. However, today part of this silt-load is diverted to irrigation channels also. But in the Harappan period, the high floods must have picked up more silt only, as there were no irrigation channels for its diversion.

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* 1 acre ft.=43,560 cubic ft.

For several other parameteres like inflow, evaporation, seepage losses, surface outflow, siltation etc., the values had to be suggested only. But even when high values were assumed for storage capacity and evaporation losses, and comparatively low values for inflow, it was obvious that the time needed to fill the available storage to such a level as would account for flooding at Mohenjodaro, would have been very short. It was obvious that even 2% silt (per volume of inflow) could not give rise to the observed 68 ft. of silt in such a short period. As evaporation, inflow and silt load are not likely to have been sufficiently different from today's value, to account for this they had to reconsider seepage and infiltration losses.

The bore hole evidence had shown that in the earliest levels of Mohenjodaro there was a thin sandy silty clay between the surface of the flood plain and the underlying extremely permeable silty sand. They argued that this layer (of silty clay and silty sand) was made more permeable by weathering and the effect of the uplift itself. The dam, caused by the uplift, they presumed would have been tens of miles long and would have been allowing the percolation of water from its upstream face. Due to these percolation losses water level would seldom be higher than the siltation level (except during floods). This would hold the surface outflow until siltation was complete. During the period of siltation, Mohenjodaro and other sites would have been under deep water. They estimated the time for a complete siltation to be 100 years or more.

Once outflow started (due to a heavy flood or erosion of the outer face of the dam), a phase of rejuvenation of the Indus channel would have been initiated. Since this implied a very short duration of 100 years or so, Raikes postulated the possibility of more than one uplift episode, separated by a period or periods of tectonic repose. On the basis of multiple layers of silt at Mohenjodaro and multilevel reconstruction, Dales (D 66) suggested five (or more) such cycles. The massive mud-brick platforms, faced with fired bricks, do show precautions against siltation or floods.

Now about the mechanism of the uplift. In the beginning Raikes thought that probably it was due to "strike-slip faults with a major overthrow of rock formations". Snead (in R 65) showed how the linear mud-extrusions, that form the crests of the Hala and Haro ranges, are associated with strike-slip faults in the pliocene-miocene rocks; these areas are also associated with sulphur springs in Baluchistan. Raikes discovered pliocene and miocene rocks with a spectacular strike-slip fault at Sehwan also; there are sulphur springs here too. Now he thinks that probably the processes mentioned by Snead may be responsible for the mud-extrusions that impounded the Indus.

At Amri there is no evidence of uplift: it probably stood where it does today at +112.0 ft. There are no indications of still water silting. On the evidence that 90% snails were of marine species Raikes infers that Amri must have overlooked an estuary or gulf in the Pre-Harappan times. With the first Harappan contacts riverine species record an increase, attaining a parity by the end of the Harappan period.

To conclude, in the words of Raikes (R 65), "A geologically plausible and hydrologically acceptable interpretation of the flood evidence is proposed that fits the known archaeological facts. Uplift or a series of uplifts of the Indus valley near Sehwan created a highly permeable barrier, the effect of which was to retain all the solids transported by the river while allowing the escape of most of its water. Mohenjodaro, and inevitably all other sites in the same general area of the Indus plain, were gradually engulfed by mud."

It was necessary to go into the details of Raikes-Dales theory because, firstly, it radically changes the concepts for the causes of the end of the Harappans; secondly, because it has become a subject of serious polemics recently. Moreover, such a vast lake around Mohenjodaro would have a drastic effect on the ecology: on the vegetation, gallery forests and the sanitation of the city. Now let us take up the criticism of their theory.

When Casal enquired, 'why was silty clay not deposited simultaneously at various levels of the (hypothetical) original *tell* of Mohenjodaro ?', Raikes (R 67a) replied, "The rate of rise of mud. . . could not have averaged more than about 9 in. per annum and may have been as little as 2 in. At this rate those determined to stay would have needed to raise their house levels only every so many years, while those who became disheartened may have abandoned their property" (R 65). The flood deposits at Mohenjodaro would represent therefore the gradual burying of those parts of the city whose owners did not erect mud-brick platforms.

Lambrick (La 67, 67a) examined Raikes's hypothesis and raised some serious objections. He pointed out that the "main theatre of siltation would be over that area in which the inflow of silt-bearing Indus water was slowed up by the resistance of the water already impounded in the lake. The zone of considerable deposit would thus move progressively backward up the 'valley' *pari passu* with the extension thither of the surface of the lake. How then could the siltation of the uplift-dam have reached as high a level as Mr. Raikes requires ?. . . . . It would already have shed burden many miles upstream".

The obstacle impounding the Indus was *ex hypothesi* of permeable material and could not withstand in the first few years the enormous impact on a narrow front of water arriving at the rate of 500,000 cu. ft./sec. in the flood season. The Allahbund— a similar mud-extrusion caused by 1819 earthquake—was breached by a mere flood of spill water coming down the Nara in 1826 (La 67).

If the argument of Lambrick is valid that the Raikes's-dam could not have been sealed upto the required 100 ft. level by lacustrine sedimentation, "it follows that the silt observed high up in Mohenjodaro could not have been deposited by such a process". And if, on the other hand, the siltation to this height is accepted, the impermeability postulated in this would make it improbable for the whole dam to have vanished without leaving any trace. The conception of multiple cutting, he says, is unrealistic. Presumably the colloidal clay could have sealed the dam which is particularly resistant to erosion or scouring.

Lambrick finds it difficult to believe that the Indus accommodated itself to such a relatively steep slope (1 in 3500). Because, if the composition of the alluvium was similar to that of today, the river's oscillations in the effort to maintain the regime-slope of 1 in 10,500 would have been catastrophic.

Lambrick (La 67a) thinks that the silt deposits at Mohenjodaro may have been either due to the disintegration of the mud bricks or consolidation of windborne silt under rain and pressure of the subsequent buildings.

For the *final* ruin of Mohenjodaro he postulates (La 67a) "an ovulsion and major change of course by the Indus (which) took, place considerably upstream of the city. The new bed being (*ex hypothesi*) lower than the old one and say, 30 miles away to the eastward, inundation spill thereafter did not approach within 20 miles of Mohenjodaro, and the surrounding country, starved of water, immediately began to deteriorate." Of course he himself concedes that this theory is not susceptible of proof.

Possehl (Po 67) has also raised some points against Raikes : (i) an oxbow lake (instead of the dam) could have engulfed the site; to engulf Mohenjodaro Raikes's dam would have to be 150 miles long; remnants of such a huge lake should be there; finally, such a dam at Sehwan should have filled the Lake Manchar niche to a comparable level, but we have several Harappan sites in the area.

I, too have a few doubts.

Raikes (R 67 b) himself admits that the siltation phase would have destroyed the gallery forest and the succeeding rejuvenation phase would have inhibited its recovery. Further, he says that the 'early' and 'intermediate' Mohenjodaro periods must have passed during the siltation phase. Dales (D 66) postulated five or more such cycles of siltation and erosion each lasting about a 100 years. As their durations are largely guess work, so we won't criticise them on that score. But if the Mohenjodaro people were living most of this time with shallow water around, the mere raising of a few houses of the 'determined people' won't do. What about the streets ? Were they raised too to be usable, or were the Harappans walking through water and mud all the time ? How was any transport possible; no carts can ply on such muddy roads.

The forests must have perished without any chance of recovery. With them the fauna too must have been destroyed or migrated. So no game would be available; nor do we expect any fish in such shallow waters. The meat supply was thus completely cut-off.

With a lake at least 30 (or 150?) miles wide, how do we expect any crops to grow around. No transport was possible through the Indus as it was impounded; the roads were quagmires; no crops could grow nearby; and the game could not survive the perpetual water—so how did the people survive even for a few days?

And what would have happened to sanitation ? Where did the drains drain ? The point to be noted is that the Harappans had to live with shallow water around them most of the time.

Can we imagine the thriving of a great civilisation with its urbanisation and planned cities under such impossible conditions. Raikes's hypothesis purports to explain the end of the Harappans, and in the process puts their very existence in jeopardy. Such a civilisation *a priori* cannot come up without optimum ecological conditions. Raikes's dam may explain the end of the Harappa culture, but makes its genesis impossible.

And how do we explain this cycle of sedimentation repeating itself again and again. Why did they not breach the permeable sand dam deliberately and solve all the problems at one stroke. The authors of a culture who could plan cities, drainage and granaries could not think of such an easy solution.

Under these circumstances we can not accept Raikes's hypothesis in its present form. More work is needed to substantiate his theories. At the moment his dam does not seem to hold water.

The Agricultural Surplus

In an earlier paper (RD 61) Raikes himself had postulated floods providing the necessary fertile alluvium for the city to thrive. Even a few decades back (before modern irrigation) the Larkana district, around Mohenjodaro, was the richest agricultural area. In fact, the conditions in the Harappan times would have been better. The annual floods due to snow-melt would not have varied much from today, but the monsoon floods would have had a flatter hydrograph because of the retardation of the run-off by vegetation. This would ensure a flood regime having less variability than today. The receding flood would have left a new layer of fertile silt. Besides, a large area of fertile soil would have absorbed water to its 'field-capacity' to a depth varying with the duration of rains which would have been sufficient for growing the grain. This, in fact, is the principle of *sailaba* irrigation in Baluchistan today. Such a fertile silty soil with its moisture retaining capacity could alone have made a sizeable crop possible.

There was abundance of fertile silt and soil. For a large scale agriculture the other requirement was a correspondingly large number of agricultural implements: for ploughing, and reaping. The fine silt was quite pliable and did not need heavy plough-shares, nor were any met with. The narrow, long axes and broad chisels were probably used for ploughing, as hoes. We had also noted that quite a number of chert blades showed signs of smoothening all over which is possible only by the friction of the soil all around the chert blade when it was being used as a hoe, probably mounted on a stick. For efficient transport of grains, they had carts, and for the storage, elaborate granaries.

The agricultural surplus so produced led to the development of various crafts. The craftsmen being full time specialists, their food needs had to be met with from the surplus. The metallurgy also flourished on this surplus. And more metal tools meant more agricultural production which, in turn, meant more fluid surplus. This surplus would have boosted the metal-industry and thus a chain-reaction would have resulted in such a large surplus that urbanisation was the natural result.

The gallery forest and the grassland would have provided the game and the rivers, fish. For the firing of bricks plenty of Kandi and tamarisk trees were there. For special purposes—for example, coffins—pine and deodar were imported from the Himalayas, probably through river transport.

The growth of civilisation, as also its sustenance, depends vitally upon the maximum harnessing of energy resources. We have evidence of the Harappans using boats with sails utilising the wind power for transport. They harnessed the cattle power too to a great extent and probably the origin of the sacredness of the cattle may have to be traced to the Indus times. The cattle power was needed both for agriculture and transport. With vast grasslands around, the bovine population could have multiplied tremendously. Possibly interbreeding of west Asiatic cattle with the Indian humped species too helped this proliferation (Fa 61). It appears that an optimum symbiotic balance was achieved between the man and the cattle in the Harappan times which boosted agriculture and trade. Thus the harnessing of a vast font of cattlepower considerably helped the process of urbanisation.

We thus see that the optimal ecological conditions, the developed tool technology, the use of wheel for fast transport, the employment of natural sources of energy in the form of cattle and wind—all led to an explosive urbanisation that is the hallmark of the Harappans.

At the present stage we do not know the exact causes for the decline of the Harappans. But one thing is clear that they flourished in a particular ecological zone. It has been pointed out that the extent of the Harappa culture coincides with the biotic region consisting of Sind, Panjab, Rajasthan as far as Yamuna, Kutch and most of Gujarat. Due to some pressures, the Harappans were being forced out from the epicentres to the periphery of this ecological zone. They continued to thrive so long they were in the same milieu; but they withered on the fringes of the Doab, which was completely an alien ecology.

Rajasthan

The great Rajputana desert—including the Thar desert—covers from quarter to half million square miles depending upon the definition used. Godbole, on the basis of excess salt in the wells of this area (than can be explained by aeolian transport) suggested that this area was a sea, even during the Harappan period (S 60). Several Harappan sites reported from Rajasthan go against this view. Now Ghosh's explorations (G 52) have shown that the ridges flanking the alluvium represent the ancient banks of the river which has been further proved by the presence of *Zootecus insularis* and *Indonaia caerulea*, fresh water shells, in them.

Ghosh (G 52) has traced the ancient river beds of Saraswati (modern Ghaggar) and Drishadvati (modern Chautang). Saraswati now dries up before reaching Sirsa, so does Drishadvati near Hissar. Saraswati is met by Naiwala channel, an ancient bed of Sutlej. Drishadvati too meets Saraswati near Suratgarh. The whole Saraswati system during its lifetime flowed into the sea either independently or as a tributary of the Indus (G 52).

Today, "between the sand banks of the river, separated from each other by 3 to 6 miles, lies a stretch of alluvium. Wherever irrigated by modern canals, it yields a harvest of summer and winter crops as rich as the Indo-Gangetic plain" (G 52). The Harappan sites were located overlooking the valleys as though the flood plains were farmed, while the later sites are on the river channels proper where the last bit of a dwindling water supply could be used.

The pattern of ancient mounds discovered by Ghosh (G 52) was very interesting. The Harappan and Pre-Harappan sites were discovered in the Saraswati and the Drishadvati rivers. Then there was a gap till the P.G. Ware people emerged in Saraswati valley breaking new ground; only a coarse grey ware site was reported in the Drishadvati. Again there was a gap and then the Rang Mahal culture appears. It is curious to observe that the Harappans came to an end around *ca.* 1700 B.C., and after them the P.G. Ware started around 700-800 B.C.—about a thousand years later (Chapter 3). Around 300-400 A.D. the Rang Mahal culture flourished—again after a millennium. In between there are no traces of settlements in this area. Obviously the habitation depended upon water supply. Do these thousand year gaps indicate some sort of a climatic cycle causing dessication with an amplitude of a thousand years?

This raises the question, how old is the Rajasthan desert? Ghosh has quoted the Mahabharat evidence (*ca.* 200 A.D.) to show the mention of these deserts. The extensive remains of the Rang Mahal culture of 3rd-4th century A.D. testify to congenial conditions again. Bryson and Baerries (BB 67) have approximately calculated the appearance of a widening fringe of desert about the Thar Desert around 1000 years ago.

Recent research (BB 67) indicates that if the atmospheric subsidence over the area were less, the moist monsoon layer would be deeper and the slight summer rainfall-maximum would be considerably larger. In fact, the desert coincides with the extent of divergent, sinking air at about 10,000 ft. Das (Das 62) found that the required diabatic cooling to maintain the subsidence amounted to about 2.4°C/day. This figure did not agree with the calculated radiation divergence of 1.8°C/ day. It has now been explained on the basis of atmospheric dust over the desert which increases the mid-tropo-spheric subsidence rate by perhaps about 50%. The major source of this dust for the Indian area is the Rajputana Desert itself. If the desert area is provided with a vegetative cover this would inhibit the raising of the dust by the wind. In the absence of this dust layer there will be less atmospheric subsidence over the area and moist monsoon layer would be deeper and the present slight summer rainfall would be considerably larger.

It is obvious that the climate was better in the Harappan and the P.G. Ware times and the rivers of the region were perennial. In the Harappan times the ecology of this area must have been exactly like Sind. The Saraswati system itself was part of the Indus, discharging into the Arabian sea. Thus we again see that the Harappa culture flourished in a uniform ecological zone. Later on Sutlej (which originally formed part of the Saraswati system through Naiwala) captured Beas and flowed into the Indus. A larger population and over-grazing probably caused an ecological imbalance between men, animals and the plants. As a consequence the vegetation cover dwindled and caused dust-layers which ultimately decreased the rainfall. It is agreed now that the Rajasthan desert is man's creation. Summarising the symposium on the Rajputana Desert Hora (Hor 52) said, "The Rajputana Desert is largely a man made desert...by the work of man in cutting down and burning forest (and by) the deterioration of soils."

Thus we see that the change of course by Sutlej and the decrease in rainfall consequent to overgrazing and deforestation affected Rajasthan more, because the Saraswati system itself dried. But the Indus continued to supply the required fertile silt and water to the arid Sind. And, as we will see below, when the Harappans were pushed to the Doab, they could not thrive in that alien ecology and withered away.

7. III. *The Doab*

The Doab means the alluvial plains of the Ganga and its tributaries. The thickness of the plains is 15,000 feet which are of the Pleistocene and Recent ages. There is ample evidence to show that originally this area was a thick monsoon-fed forest. The present alluvial plains are a result of heavy de-forestation over millennia at the hands of man. This area falls within the rainfall contours of 25″-40′ (Fig 21). "The soil is meadow type and tropical and tropical steppe on older alluvium and hard rocks with solonets" (Sp 63). The older alluvium (*Bhangar*) was kankary and very difficult to plough without the massive iron ploughshares. "The Gangetic plain botanical province has through the influence of man in the course of untold generations lost much of its primeval apperance. There are records of its being covered at one time by vast forests of Sal which have now all but disappeared except on the slopes and at the base of mountain boundaries" (Cald 37). Pant

(Pt pc) says, "The fauna of the Siwaliks included carnivores, monkeys, elephants and ungulates suggesting that the Indo-Gangetic plain must be having a rich forest flora like that of Tarai and Bhabhar regions of the present days." Stebbing (St 22) who wrote the authentic monographs, "The Forests of India", also points out to the primeval thick forests in this region. Singh (Sin pc) says that the monsoon-fed forests and swamps on the river banks of Doab may have continued to persist for most of the period 4000-2000 B.C. Panikkar (Pan 55) has pointed out that during the periods of Rama's story, the colonisation of the plains of India had not been complete and the great centres of Ashram life were deep in the forest in the heart of Hindustan. Basham (Bas 63) says, "The main line of Aryan penetration was not down the river, the banks of which were then probably thick swampy jungles, but along the Himalayan foothills". Even as late as the Moghal times there were forested patches as evidenced by their hunting expeditions (Sp 63). Kosambi (Ko 63) also said, "The Gangetic basin with its very fertile soil but much greater rainfall was under dense forest".

Pollen analysis work is now being undertaken by the palaeobotanists in India. In the old Doab soils too the ratio of non-tree-pollen to tree-pollen (NTP/TP%) should probably be less than hundred, indicating a dense forest, like the Blackmore moreland which was shown to be a dense forest in prehistory on the basis of NTP/TP percentage (Di 61). The only evidence now available from Hastinapur (CG 54-55) indicates the presence of wild sissoo (*Dalbergia sissoo*) and Kurchi (*Holarrhena antidysentrica*) and shows that there was no climatic change in the past. Wild cane and rice were also reported. Lal (Lal 54-55) had submitted six soil samples from Hastinapur for pollen analysis, out of which four were rich in pollen. Except for 'Pinus', no other species was idenfied at that time. Though the evidence for forests in the Doab on other grounds is conclusive; yet pollen analysis alone will give the details of the particular species thriving at that time.

The sharp cuts on some identified bones from Hastinapur show that the people were eating beef, venison and pork.

We may digress here, to assess the significance of the presence of rice and the horse *vis-a-vis* the Aryans.

Rice has been reported from the P. G. Ware levels at Hastinapur. It has also been found in phases II-IV at Navdatoli. The recent discoveries of rice from Lothal and Rangpur deprive it of any ethnographic significance. Wild rice grows in the marshes of central India, Rajputana, etc., and may have been cultivated by the Saurashtra Harappans, as also the Navdatolians.

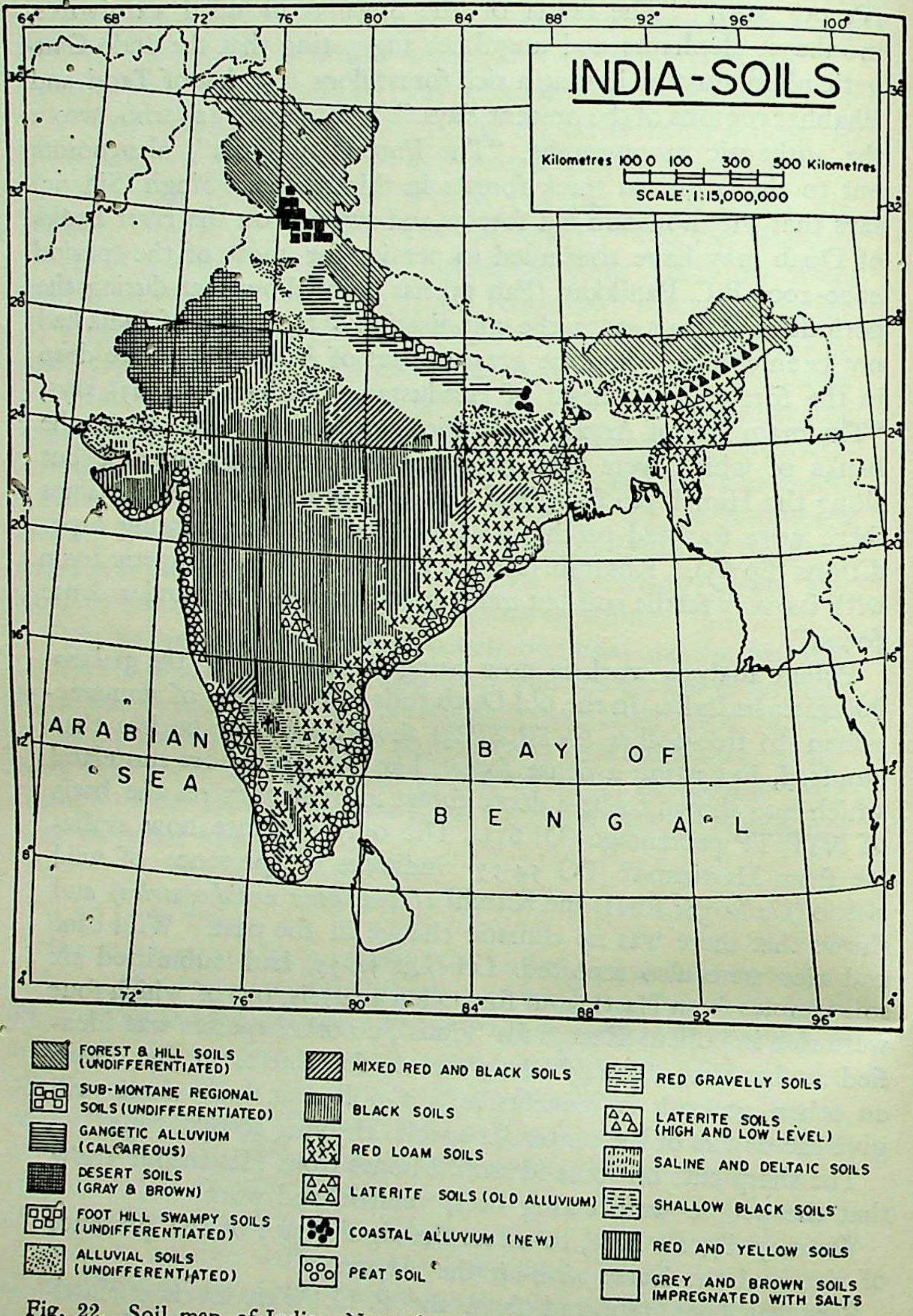
INDIA-SOILS
Kilometres 100 0 100 300 500 Kilometres
SCALE 1:15,000,000
64° 68° 72° 76° 80° 84° 88° 92° 96° 100°
36 32 28 24 20 16 12 8 4
ARABIAN SEA
BAY OF BENGAL
FOREST & HILL SOILS (UNDIFFERENTIATED)
SUB-MONTANE REGIONAL SOILS (UNDIFFERENTIATED)
GANGETIC ALLUVIUM (CALCAREOUS)
DESERT SOILS (GRAY & BROWN)
FOOT HILL SWAMPY SOILS (UNDIFFERENTIATED)
ALLUVIAL SOILS (UNDIFFERENTIATED)
MIXED RED AND BLACK SOILS
BLACK SOILS
RED LOAM SOILS
LATERITE SOILS (OLD ALLUVIUM)
COASTAL ALLUVIUM (NEW)
PEAT SOIL
RED GRAVELLY SOILS
LATERITE SOILS (HIGH AND LOW LEVEL)
SALINE AND DELTAIC SOILS
SHALLOW BLACK SOILS
RED AND YELLOW SOILS
GREY AND BROWN SOILS IMPREGNATED WITH SALTS

Fig. 22. Soil map of India. Note the distribution of black-soils, desert soils, the Gangetic alluvium and red loam soils.

Horse remains also were recovered from Hastinapur and were adduced as evidence to suggest Aryan association. It may be noted that at Mohenjodaro horse bones (near the surface) and a terracotta horse head have been found. Lothal too has yielded evidence for the use of horse. Ross (Ros 46) reported four horse teeth (of *Equus Caba llus*) from the lowest levels of Rana Ghundai. Thus the horse was used in the pre-Harappan and the Harappan times too. Therefore one can't theorise about the Aryans on the basis of the presence of horse.

The evidence mentioned above shows that the Doab with its primeval dense forests and the hard calcareous soil (Fig. 22) was not a congenial place for settled agriculture in the Copper-Bronze Age. It is clear (Chapter 2) that before the P.G. Ware period no large settlements were there. Even the P.G. Ware presents the picture of a village life with a limited agriculture. Only in the N.B.P. times do we have the cities coming up as a result of large scale agriculture which was made possible by the abundant iron implements. The iron was coming from Bihar, so also the N.B.P. The Doab needed heavy iron plough-shares to produce the agricultural surplus needed to usher in the urbanisation. Kosambi (Ko 63) refers to the use of word *phala* for plough-share in a Pali *Sutta Nipata* datable to *ca.* 500 B. C. This text also mentions 'quenching' which could only be possible for steel and not copper (Chapter 6). Only at Atranjikhera we get a good number of iron tools from the P.G. Ware levels. There is no doubt that the P.G. Ware people started colonisation of the Doab with iron implements. But large agricultural surpluses were possible only in the N.B.P. times with the profuse availability of the Bihar iron. The real strength of iron lies in its mass abundance. It was this abundant iron that was responsible for the urbanisation of the Doab in *ca.* 500 B.C. No cities were possible before that.

On the western fringes of the Doab we do get evidence of the Harappans. But the Harappans could not thrive in a region of heavy rainfall and dense forests; they withered away in this alien ecology. The Copper Hoards people did not have any permanent settlements as the hoards so far recovered are from flat fields and never from any mounds. The formation of mounds needs sedentary life and agriculture on a larger scale. They did not have any pots or pans of metal, which again shows their nomadic character. Their tool kit was ideally adapted to a hunting-nomadic life: the axe to cut wood; the harpoon for big game and big fish; the anthropomorph for killing birds; and the antennae sword for trapping big game (Chapter 6). But copper-technology was no answer for large scale agriculture in the Doab with its primeval forests. The Doab urbanisation had, therefore, to wait till the advent of iron.

Speaking of the Doab, Wheeler (W 59) had once said, "No part of India has been changed more drastically by the encroachment of tillage on jungle, and the first act of the historical imagination must be to replant 'the dark and pathless forest, the '*mahavana*''. Above we have tried to 'replant' this '*mahavana*' and the result is obvious: the presence of any cities before the 5th-6th centruries B.C. in the Doab is both improbable and incongruous.

7. IV. *The Central Tableland*

In this area are included the Satpura ranges, and the plateaux of Malawa, Baghelkhand and Chota Nagpur. Even today these areas are populated by the hill tribes. The altitude ranges from 300 to 600 metres (above M.S.L.). Subbarao had included a large portion of this tableland also in his 'perennial nuclear region'. Here again he was influenced by the present day cultivation of the black-cotton-soil. It may be noted that most of this area is rocky with a layer of black-cotton-soil which probably has been derived from the decay of the vegetation. Mujumdar (in S 67a) thinks that this soil, on which the Navdatolians settled, is an *in situ* weathering of the brownish silt. With the modern technology it is possible to cultivate this black-cotton-soil profitably, but still nothing could compare the fertile silt brought by the rivers, say, of the Doab. A look at the population map would show that despite the big rivers like Narmada, Tapti, Godavari, etc. these areas are sparsely populated, because the rivers pass through the uplands only. But the Godavari delta is thickly populated, as it is there that the river deposits its fertile silt.

The Chalcolithic people with their poor copper technology could never cultivate the sticky black-cotton soils. It requires heavy and sharp iron agricultural implements. For agriculture they had to confine themselves to the narrow alluvial strips of Narmada or Betwa. With this ecology no large-scale agriculture and hence not much fluid surplus—was possible. Thus though the milieu was congenial for village-agriculture, it was not conducive to urbanisation. That is why the Chalcolithic cultures could never come out of the village status. Sankalia (S 67a) has, in fact, estimated that in the earliest settlement of Navdatoli there were only about 150 inhabitants.

Several plants were cultivated by the Chalcolithic people. The species grown during the Chalcolithic period (BMG 61) were wheat (*Triticum vulgare-compactum*), rice (*Oryza sativa*

L.) from Navdatoli phases II-IV, lentil (*Lens culinaris* Medikus), black gram (*Phaseolus mungo* L.), green gram (*Phaseolus radiatus* L.,) grass pea (*Lathyrus sativus* L.). linseed, (*Linum usitatissimum* L.), ber (*Zizyphus jujuba* L.), myroblan (*Phyllanthus emblica* L.). It is curious to note that the cold weather species outnumber the others. Does this indicate a colder climate in the past ?

The rocks in the area provided the material for stone tools. Dolerite occurs abundantly in the Deccan lavas for making ground celts. The fragile pink vescicular rock of the Deccan trap abounds in the secondary minerals like chalcedony, agate etc. which were used for making stone tools by the Chalcolithic people. Chalcedony nodules were noted by Sankalia (S 67a) in Narmada gravels too. The Banasians however never used the microliths, which could be either due to lack of material or different traditions. Though at Navdatoli practically every household made its own stone tools (S 67a).

In Chapter 3 we had noted the probable migratory route of B-&-R Ware. To recapitulate, on the basis of growingly younger C^{14} dates, we had seen the first emergence of B-&-R Ware in Saurashtra, then in Rajasthan at Ahar, then in Navdatoli on the Narmada, finally in Rajar Dhibi and Chirand. We saw that most of the Doab is free of this early variety of B-&-R Ware; it does not penetrate the Doab beyond Atranjikhera and West Bengal beyond the Sunderbans. The barriers again were ecological. Both in the Doab, as also in West Bengal, dense monsoonal forests probably hindered the penetration.

Conclusion

The foregoing discussion clearly indicates that though the ecology does not absolutely determine the social development, it does help—as also hinder—its course. The technology assists man in wresting himself free from the ecological determinism. But the technology has its own limitations for a given type of ecology. The same copper-technology, which provided us the first (Indus) civilisation in the semi-arid ecology of Sind and Panjab, failed to usher urbanisation into the Doab. The Harappans themselves withered away in the moist, forested and tangled country of the Doab. To urbanise the Doab the plentiful supplies of Bihar iron were required, hence the first cities of this part are about two millennia later than those of Sind and Panjab.

CHAPTER 8

THE CLUES AND THE EMERGENT PICTURE

IN THE PREVIOUS pages, I tried to bring multifold data to bear upon the archaeological problems. These studies on the chronology, the technology and the ecology did throw out clues towards the solution of the problems formulated in Chapter 2, which will now be summarised below (Sec. 8.I.). The emergent picture (Sec. 8.II.) will be delineated in the second part by interpreting this evidence. The clues are objective facts, but to propose a 'model' for the data obtained, one has to have conjectures; and so long as they are logically consistent one need not fight shy of them. The ultimate aim of our enquiry after all is the reconstruction of the past.

I began (Chapter 1) by emphasising the need and the utility of a cross-disciplinary approach for the resolution of the archaeological problems. The archaeological evidence was marshalled, albeit tendentiously, to emphasise the problems which I hoped to tackle in the course of this multiple study. In the subsequent chapters the chronology, the technology and the ecology of the protohistoric cultures were dealt with. The salient points are given below:

8.I. *The Clues*

A. Archaeological Clues.
B. Chronological Clues
C. Technological Clues
D. Ecological Clues

I.A. ARCHAEOLOGIAL CLUES

The north-west, before the Phase E, shows (Chapter 2) a bewildering variety of cultures. The Phase E heralds some uniformity, many new traits bringing the area to the threshold of urbanisation. In Mundigak IV, a 'palace' and a 'temple' appear; in Kot Diji I and Kalibangan I there are fortifications; even in Amri II traces of rampart were met with. The potter's marks (precursors of writing) first appear in Mundigak IV and Damb Sadaat II. The incised grey ware vessels are ubiquitous now. The polychrome tradition is giving way to the black-on-red decoration, suggesting uniformity and utilitarian values. The settlements near the Indus plains, like Amri, alone were urbanised; but none in the uplands. Naturalistic motifs dominate the geometric ones; the bull motif becomes widely popular.

The Harappa culture, arriving apparently full-blown, explodes on the scene. The whole area, no doubt, was on the threshold of urbanisation, and the Harappans did borrow from the Pre-Harappans. But the Harappan innovations far outnumber the derivations. The upsurge is evident in the variety and the richness of metal artifacts, the pottery, the structures of burnt bricks and in the planned towns. The delicacy of the Kot Diji pottery-decoration and the multiplicity of the upland motifs give way to the dull uniformity of the Harappan art-forms.

The Chalcolithic cultures present a definite set-back in every sphere. The settlements are smaller, the metal is meagre. There is again a multiplicity of traits, the long Harappan chert blades are replaced by the short blades, the metal technology is retrograde.

The Harappa culture devolves into degenerate cultures in Saurashtra. But Rangpur II C is marked by a profusion of paintings, the popularity of the B-&-R Ware and the emergence of the L. R. Ware. The graffiti show motifs like tent, rider and the sun. The story of this resurgence is repeated at Desalpar, Prabhas Patan, Lakhabhawal and Somnath.

The Banasian sites are marked by the absence of microliths. Here too the B-&-R Ware is popular. There is a profusion in pottery styles (the ribbed ware, the cut ware, the buff ware, the almond tan ware, the cream slipped ware, etc.). Big houses, 30′ × 15′, even 100′ × 80′, are in evidence; so also the communal hearths. Burnt bricks are in use. The gamesmen are of the Indus type.

In contrast to the immediately post-Harappan cultures, where big houses and communal hearths indicate a communal way of living, the Malwa and Jorwe cultures show the small individual huts only.

The P. G. Ware village settlements show a westerly distribution, in contrast to the easterly N. B. P. Zone. The P. G. Ware is a painted ceramic with a controlled firing to impart its characteristic grey hue. On the other hand, the N. B. P. is an unpainted ware with a deliberately achieved black colour and a gloss. The red ware-shapes, associated in the west with the P. G. Ware (e.g., Hastinapur), occur with the N. B. P. in the east (e.g., Sravasti).

I.B. CHRONOLOGICAL CLUES

On the basis of the analysis of the C^{14} dates and the re-examination of the archaeological evidence (Chapter 3), the following chronologies were proposed:

(i) Pre-Harappa cultures :
  (Phase E)—*ca.* 2700-2400 B.C.
  Kot Diji I—*ca.* 2600-2240 B.C.
  Kalibangan I begins *ca.* 2400 B.C.
(ii) Harappa Culture :
  Metropolitan areas—*ca.* 2350-2000 B.C.
  Peripheral regions—*ca.* 2200-1700 B.C.
(iii) Chalcolithic Cultures :
  The inclusive timespread—*ca.* 2000-1100 B.C.
  Banas culture—*ca.* 2000-1600 B.C.
  Malwa culture—*ca.* 1700-1400 B.C.
  Jorwe culture—*ca.* 1400-1100 B.C.
  Eastern cultures—*ca.* 1300-700 B.C.
  (Chirand, Rajar Dhibi, etc.)
(iv) P. G. Ware—*ca.* 800-400 B.C.
  N. B. P.—*ca.* 550-100 B.C.

These major points may be noted :

(a) The metallurgy of the Harappans is about 2000 years later than that of Iran;
(b) The coincidence in time of the end of the Harappans and the beginning of the Banasians;
(c) The growingly younger dates of the B-&-R Ware starting from Lothal to Rajghat (Fig. 10); and
(d) The part contemporaneity of the P. G. Ware and the N.B.P.

I.C. TECHNOLOGICAL CLUES

The copper smelting probably originated in Iran, Tal-i-Iblis being one of the earliest sites. The contacts with the eastern regions of this site go back to Rana Ghundai II times. At Mundigak, we see the developmental stages of metallurgy but the Harappan metallurgy appears fully developed on the scene. It is *ca.* 2000 years later than Iran and thus any independent origins are precluded. I also justified the distinction between the truly Chalcolithic cultures (Banas, Malwa, Jorwe) and the neolithic cultures of the south (Chapter IV).

The chemical and metallographic data (Chapters 5 and 6) gave the following clues:

(i) *Pre-Harappa Culture*

(a) Though the metal is meagre, there is evidence of low-tin bronze from Mundigak I and of lead-alloying at Nal.

(ii) *Harappa Culture*

(a) Seventy percent tools are unalloyed, indicating scarcity of tin;

(b) Alloying was more common in the upper levels than in the lower ones;

(c) The tin-content varied widely; only 14% bronzes contained tin in its optimum range of 8-12%, indicating lack of control or knowledge of correct proportions for maximum strength and ductility;

(d) The main types made of tin-bronze were the knife, the chisel, and the axe;

(e) Only 8% tools showed arsenic-alloying, 4%, nickel alloying, and 6% lead alloying;

(f) There is a high probability* of the extensive use of the oxide-ores and native mineral as compared to the sulphide ores (in fact, large quantities of oxide-ore have been recovered).

(g) Sulphide-ore smelting was probably known right from the beginning indicating the use of mature copper technology from its very inception, as a result of diffusion;

(h) The spectroscopic analyses of the tools and Khetri ores show fairly good correspondence, indicative of the probable use of these ores;

(i) The metal forging techniques of 'sinking', 'raising', 'running on', cold work and annealing, rivetting, lapping, closed casting and *cire perdue* were known, which places them on the top of all the other, copper using cultures; and

(j) The Harappa culture is richest of all the rest in metal abundance.

(iii) *Chalcolithic Cultures*

(a) Alloying generally shows tin in 1-5% range, unlike the higher content of the Harappans;

(b) Though lead (1-2%) was alloyed for better fusibility, no arsenic-alloying is known, thus differing from the Harappans;

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* Based on the relative probability calculations of the chemical data.

(c) No tin-alloying is evidenced from Ahar, thus marking them apart;

(d) The probability of the exclusive use of oxide ores and native minerals indicates access to fresh ore deposits of the same copper belt;

(e) The spectroscopic analyses of the Khetri ores and the Chalcolithic artifacts indicate close correspondence which may mean the use of the same copper belt by the Harappans and later on by the Chalcolithic cultures;

(f) Open casting, cold work and annealing were known, but none of the advanced techniques of the Harappans;

(g) The metal abundance in comparison to the Harappans and the Copper Hoards is less, but far more than the neolithic cultures;

(h) At Ahar, copper smelting is attested to which entitles them to a Copper-Bronze Age status; and

(i) The developed and unique copper technology of the Kayatha culture raises possibility of the independent origins of the Chalcolithic cultures.

(iv) *The Copper Hoards*

(a) The analyses of (my five and one Lal's) samples showed absence of alloying which marks them apart from the rest of the bronze-using cultures;

(b) Though closed casting was known, no cold work or annealing (for increasing the hardness of copper) was attested to; and

(c) In metal abundance, they are only second to the Harappans, indicative of an access to rich ore deposits.

(v) *The P. G. Ware and the N. B. P.*

(a) No alloying is attested to at Hastinapur Pd II;

(b) The presence of a copper arrowhead (frequently an irretrievable missile) at Hastinapur Pd II indicates greater use of copper, as also the complete absence of iron;

(c) At Atranjikhera, however, there is plenty of iron in the P. G. Ware Pd; and

(d) The real abundance of iron is associated with the N. B. P. which indicates the advent of Bihar iron.

The Typological Analysis

(i) The socketed axe is known from Mesopotamia (Uruk Fd), Hissar IIIC, Mundigak III, 6, a terracotta model from the early levels and an actual type from the upper levels of Mohenjodaro, thus precluding its association with the later Aryan waves only;

(ii) The distinctive Harappan types are the double-edged razor, the knife with curved ends, the broad tanged chisel, the barbed arrowhead and the barbed and eyed fish hooks;

(iii) The prolific so-called narrow axes, broad chisels, 'shoe-last', chert blades (smoothed all over), and knives were probably used as agricultural implements by the Harappans;

(iv) In contrast, the Harappans expended so little metal on the weapons as shown by the extremely thin spearheads and arrowheads as also by the rare occurrence of swords (total four);

(v) There are no diagnostic Chalcolithic tool types;

(vi) The distinctive Doab Zone Copper Hoard types are the anthropomorph, the antennae hilted sword and the barbed harpoon (all suited for a hunting nomadic life);

(vii) The Plateau Zone of the Copper Hoards does not have any distinctive type, excepting the barcelt (the leverage provided and its sturdiness suggest its use for mining);

(viii) Flat and shouldered celts are common to both the zones; and

(ix) In contrast to the profusion of metal pots and pans in the Harappa culture, there are none in the Chalcolithic and the Copper Hoard cultures.

I. D. ECOLOGICAL CLUES

(i) The trellis-patterned basins, the steep craggy outcrops and the few oases of Baluchistan were deterrent to contacts and communication thus promoting the growth of disparate cultures;

(ii) The spatial extent of the Harappa culture coincides with a uniform ecological zone comprising semi-arid land watered by perennial rivers and is similar to Egypt and Mesopotamia where too the earliest civilisations flourished;

(iii) The gallery forests sustained by the Indus could have been the habitat of the tiger, the buffalo, the rhinoceros, etc. and do not indicate wetter conditions;
(iv) No major climatic change is attested to in the Sind and Baluchistan in the last 5000 years;
(v) There is no probability of any dam impounding the Indus and engulfing the Harappan cities for any length of time;
(vi) The Saraswati and the Drishadvati were part of the Indus system in the Harappan period thus including Rajasthan in the ecological zone of the Harappans;
(vii) Rajasthan was watered by perennial rivers until the P. G. Ware Pd;
(viii) The Doab was a monsoonfed forest with kankry soil requiring heavy iron plough-shares and axes in abundance for large-scale agriculture;
(ix) The Chalcolithic cultures were confined to the narrow alluvial strips thus limiting the production of agricultural surplus;
(x) The sticky black-cotton soil could only be cultivated with abundant iron tools which precluded its cultivation by the Chalcolithic peoples ; and
(xi) The Deccan trap was rich in secondary minerals like chalcedony and dolerite, both used for making stone tools by the Chalcolithic people.

8.11. *The Emergent Picture*

The clues enumerated above do indicate a cross-disciplinary multi-pronged approach, but I called it an 'integrated' study—what about that ? Using these clues I will now attempt an integrated reconstruction* below. The model, proposed to explain the obtained data, will be a " 'true' one in so far as it does satisfactorily explain the phenomena, but you can have more than one model at a time, all 'true' " (Pi 66).

The Pre-Harappans

In the north-west, the Indo-Iranian borderland, a multiplicity of disparate cultures probably reflected the ecology of the narrow basins and the confining mountain ranges. The metal (copper) was known but in the given milieu any large scale agriculture providing fluid surplus to support full-time metallurgists was not feasible; nor could it give rise to urbanisation. The cultures which came down to the Indus plain (e. g., Amri) alone could contribute to the civilisation-making process. The proliferation of humped bull motifs may signify the recognition of the cattle power for transport and agriculture.

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* For detailed references refer to the relevant chapters.

Socio-economically, the development in metallurgy, the improvement in agriculture, the harnessing of cattle power (as shown by the popularity of the bull motif also), and trade (contributing to prosperity as well as cultural uniformity) were bringing the whole area in Phase E from Afghanistan to the Indus to the threshold of civilisation. But why did it flower in the Indus basin alone ?

The Harappans

It could be due to the availability of the fertile Indus alluvium spread over a vast area. The earliest civilisations of the Nile and the Euphrates too came up in a similar ecology of semi-arid plains watered by perennial rivers. The agricultural surplus produced on the Indus plains would need marketing centres. These centres could have led to the civic authority who would manage the business and maintain law and order, and in return would get taxes and tributes. Craftsmen would thrive because they could now exchange their goods for grain. Possibly, recurring floods gave the impetus for a new trade-centre which would be built on a raised platform, managed by a central authority. This authority could easily have dictated the standards and uniformities in style. And if these cities were pre-planned, where is the chance of finding the nebulous beginnings below them ?

The power of this authority may have grown from the middle man's functions and privileges. But two more significant factors could have played a crucial role in augmenting their power and the prosperity of the society : the discovery of local mines of copper ores; and the deposits of fine chert of Rohri and Sukkur. The group of people who held the monopoly of these ores and chert mines must have assumed the leadership too. The role of metals in boosting the economy should have been crucial indeed.

Once the fertility of the Indus plains was recognised, large scale agriculture required an abundance of agricultural implements, transport and manpower. Given these and a proper organisation the sky was the limit to agricultural production. The pliable Indus plains, unlike the black-cotton soil of Malwa or the kankry Bhangar of the primeval Doab, did not require heavy iron ploughshares. The copper hoes (the so-called narrow long axes and broad chisels), even the chert blades mounted on sticks were enough to plough these pliable plains, as no deep ploughing was required. Ploughing could explain many blades that were found smoothed all over. The stone 'shoe-last' may also be an agricultural implement. Kosambi has identified harrows also on the seals (Ko 65). The richness of the metal inventory must have boosted the agricultural production.

The weapons, however, are poor, reflecting peaceful conditions. With the fertile land of the seven tributaries of the Indus available, there was no use of war for land. They had plenty of land, enough of metal sources and abundant manpower (settled communities breed faster). So where was the need for war? War, after all, is only an economic necessity.

[illegible] land [illegible] defence

The use of the wheel, cattle, horse and camel, the river and the wind for transport on a large scale made the movement of grain and trade feasible over large areas. Lapis lazuli and gray ware urns showed the beginning of trade in Phase E itself. Pine and Deodar trees must have been floated down the Indus from the Himalayas. The Harappan ports on Makran coast and the dockyard at Lothal attest to maritime trade. Representation of a craft with a mast and a yard is available from Mohenjodaro. The trade and contacts with Mesopotamia have been discussed before. The merchant houses at Ur had 'striking technological reflection of Harappan brick work' and the traded items were copper, sissoo wood, onions, ivory and peacock (Mal 65; Bib 65; E 65). The 'Copper from Meluhha' (Le 59) may have been the Rajasthan copper exported to Mesopotamia.

The quantitative changes towards urbanisation were taking place from the Phase E itself. The Harappans stand out because of a qualitative change: the transition from village to city life. The sumptuous agricultural produce provided the essential surplus on which is based the city life. The merchants, the clerks, the craftsmen, the potter and the metallurgist did not have to produce for themselves; they were provided for from this fluid surplus. More tools and better transport meant more surplus, which, in turn led to further development of the industries. This chain reaction made the sudden explosion of the Harappa culture possible. Probably the vagaries of the Indus and the insecurity of village marketing centres made the laying out of the planned cities of burnt brick on raised platforms an imperative. The rulers (merchants) needed the security of the citadel, the Granary served as the treasury, and the writing was necessary for the accounts. The central authority enforced standardisation in arts and crafts.

Its power was enhanced by the monopoly of the copper and chert mines.

But in a more subtle way this uniformity was also a reflection of the uniformity of the ecological zone in which the Harappans thrived. Sind, Panjab and Rajasthan were semi-arid areas watered by the Indus system; Saraswati and Drishadvati also were a part of it. But when the Harappans were pushed into the alien ecology of the wooded and tangled country of the primeval Doab, they withered.

why?

The Harappa culture was never an extensive empire—it was a shifting phenomenon both in time and space. In the metropolitan epicentre it started (Chapter 3) around *ca.* 2350 B.C. and came to an end *ca.* 2000 B.C. But in the peripheral zone, where it was pushed to, by nature or the intruders, it lingered on till *ca.* 1700 B.C.* The change in the peripheral zone is obvious. The mother-goddess figurines vanish; instead, the fire-altars appear at Lothal and Kalibangan in each house, which were not known in the metropolitan area. New burial customs appear. The refuse and animal remains lay littered over the streets of Kalibangan, there was no drainage in the streets—these are evidence of the weakening of the society and the degeneration of civic standards.

The Harappa culture was an explosive evolution, but not an import. The metallurgical know-how had already diffused from Iran, hence we get a full-blown technology right from the beginning (Chapter 4).

The causes for the end of the Harappans are not clear. Conceived to explain the end, Raikes' dam instead puts the very genesis of the Harappa culture in jeopardy. The flowering of a civilisation requires optimum ecological conditions. A culture fighting for sheer survival all the time against an ever encroaching mud-lake could never explode into urbanisation (Chapter 7).

Not necessarily?
true Toynbee

As far as the devolution of this culture is concerned, we see a gradual transition in Saurashtra. The Banas culture shows some borrowings from the Harappans too. But the other Chalcolithic cultures, in tools, pottery and technology, are completely dissimilar to the Harappans. The Harappan metallurgy showed greater advance over the other cultures, in having the know-how of arsenic-alloying, *cire perdue*, vessel making techniques, sulphide ore smelting and in the richness of metal.

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* It is interesting to note here that all references to Meluhha in Mesopotamian texts cease by *ca.* 1750 B.C., a fact suggestive of the end of the Harappans (Ko 65).

The Chalcolithic Cultures

The Harappa culture comes to an end *ca.* 2000 B.C. in the metropolitan areas and at the same time the Banasians emerge on the scene. The latter are obviously more degenerate in material traits than the Harappans. The Banasians knew copper smelting, lead alloying and open casting but have none of the advanced technology of the Harappans. Even the flat celts have puckered surfaces due to gas holes. We get evidence of big communal hearths, large houses of 30′ × 15′, even of 100′ × 80′. Kiln-burnt bricks were known. The uniformity of the Harappan black-on-red is violently replaced by a plethora of ceramics. The shapes and motifs of the west Asian vintage were noted by us earlier (Chapter 3). On the other hand, the black-on-red ware, dish-on-stands, painted B-&-R Ware, the Indus type of gamesman, the use of burnt bricks and even the twin mounds of Gilund are traits of Harappan affinity. Sankalia (S 60) had long ago hinted at their Harappan contacts.

The following circumstantial evidence is very suggestive: (i) the end of the metroplitan Harappans and the emergence of the Banasians coincide in ca. 2000 B.,C.; (ii) Desalpar IB assemblage shows close resemblance to the Banasians, though IA is Harappan; (iii) the break in technological tradition as evidenced by the lack of stone tools and the poor copper technology (compared to the Harappans); (iv) several Banasian traits indicating Harappan borrowing; (v) the vague west Asiatic affinities indicating acquaintance of the areas traversed rather than the actual imports; (vi) the distribution of the B-&-R Ware in Saurashtra, Rajasthan, pre-P. G. Ware western Doab, and the east Panjab (Dik 67); and (vii) the presence of the Indo-Aryans in Mesopotamia already in *ca.* 2000 B.C. (Bib 65).

The aforementioned evidence can plausibly be explained (Ag 66) by the equation* of the early Aryans with the Banasians. The Aryans could not be easily detected archaeologically, as they had adopted the material traits of the vanquished cultures (as they had done in Mittani). Cook has pointed out the case of the Dorian invasion in Greece (*ca.* 1100 B.C.) which did not leave any archaeological traces as the invaders "being more primitive than the people they conquered took over their basic arts and crafts" (Coo 60). But the vague western affinities, the Harappan borrowings and the sudden variety in pottery may probably indicate that the Harappan craftsmen were trying to cater to the new exotic masters. The individuality of a culture comes later, as a result of sedentary life.

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* To me this model seems to explain the circumstantial evidence best. This does not deny the probability of other models.

The appearance of big houses and community hearths characterises the Banasians and the Rangpur IIC people, etc., and shows a communal way of living (different from the Harappans, as also from the subsequent Malwa and Jorwe cultures). The graffiti marks showing the rider, the tent and the sun at Rangpur are also quite suggestive of the Aryans.

In Figure 10, the probable migratory route of the B-&-R Ware on the basis of the growingly younger C^{14} dates shows that the Banasians borrowed it from Lothal. The first contact seems to be in the Saurashtra, where (Sec. 8-I) a resurgence in Rangpur IIC and Desalpar IB and several other sites can be discerned. A predilection for the B-&-R and L. R. Wares is already in evidence. Sinha (Sinh 60), on literary grounds, has suggested that the early Aryans came by sea, thus making the proposed hypothesis, of the early Aryans entering from the sea and contributing to the end of the Harappans and adopting many of their traits, quite plausible. We had also noted the ecological barrier they (the B-&-R Ware people) faced in penetrating the Doab and West Bengal as their copper technology could not cope with the colonisation of these thickly forested areas.

The occurrence of rice and the horse both in the Harappa and post-Harappa cultures deprives them of any diagnostic value for establishing any Aryan equations.

The Malwa and the Jorwe cultures show improvement over the Banasians in metal forging e.g., the Navdatoli axes and the Chandoli dagger. They know alloying, but the tin content is below 5%, no arsenic alloying and closed casting is attested to. The metal is meagre. For this the ecological limit on the agricultural surplus was one reason. The other could be that they could not smelt sulphide ores and the surface oxide ores could have been exhausted from the mines used. But there are no distinctive tool types which could establish their contacts with the Harappans or the Copper Hoards. We saw how the Chandoli dagger is technologically much different from the Copper Hoard types. The enigmatic Kayatha culture raises a strong probability of the independent origins of the Central Chalcolithic cultures. No doubt, the B-&-R and L.R. Wares and a few other items point to contacts with the Banasians.

Could it be [illegible]

Despite their copper technology, the Chalcolithic villages remained villages because of the limits imposed by the ecology. The narrow alluvial strips of the Betwa and the Narmada could support only small villages. Sankalia, who has proposed an integrated reconstruction of the socio-economic life of the Navdatolians (S 67a), has estimated that the earliest settlement had about 150 inhabitants only. The surplus needed to provide for the growth of technology, classes and the state could not be produced. And the sticky black-cotton soil for extensive agriculture needed iron tools. The secondary minerals in the Deccan traps and the river gravels (S 67a) provided chalcedony and other rocks for the stone tools. They borrowed some traits from the long continuing Neolithic culture of the south and probably traded some of the metal with them. But the differentiation of the classes in the society, as evidenced by the developed art of the Chalcolithic pottery as also of the metal-smith, does place them in the Bronze Age. Though probably each household was preparing (S 67a) its own stone tools.

The Copper Hoards

The Copper Hoards depict richness of metal, as by now probably the Singbhum ores had been tapped. Their epicentre was the wooded plateau of Chota Nagpur, starting with simple celts and barcelts; the latter probably were used for ore extraction. Probably, the metallurgy here is a diffusion from the south-east Asia (Chapters 4 & 6) or had an independent origin. The mythical skills of metallurgy earned the smiths economic release from the kinship bonds of the tribe thus making them itenerant. They probably moved to the Doab and catered to the needs of local tribes there.

The thick primeval Doab forests were rich in game, so were the rivers in fish. The anthropomorph (a missile to hurl), the antennae sword to trap big game, the harpoon to kill big fish and crocodiles and the axes to clear patches of the wood were made by these itenerant smiths in exchange for food and other needs (Chapter 6).

They knew closed casting and smelting, but probably did not know alloying or annealing and cold work for hardening the tools. The typology of the tools is very distinctive and proves their unique character without any links with the Harappans, the Chalcolithic cultures or anything western. They had an indigenous culture probably influenced by the south-east Asian cultures. The richness of metal here is entirely due to the abundant Bihar ores and does not reflect an advanced economy. Out of a thousand artifacts, absence of even a single pot or pan speaks volumes for their nomadic nature. No mounds of the Copper Hoards, indicating se-

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dentary life, have been reported so far; all the reported Copper Hoards are from plain fields. The reason again was ecological. The kankry soil of the Doab needed heavy iron plough-shares. Copper was never abundant in the past; nor is it even today. Large scale clearance of the thick primeval forests too needed heavy axes on a large scale. The copper technology could not cope up with the problems of the large scale settlement in the tangled country of the Doab. For that, one had to await the advent of the Iron Age.

The odd assortment that goes by the name of the Copper Hoards may have to be drastically trimmed on the availability of stratified evidence. But, even now, the double axes, the Kallur sword, etc., may better be removed from the fold of the Copper Hoards.

There are no dates for the Copper Hoards. But there is circumstantial evidence to place the Doab Copper Hoards between *ca.* 1100-800 B.C.—they are post-Chalcolithic and confined to the Doab and the Chota Nagpur plateau.

The P. G. Ware

The (pre-P.G. Ware) B-&-R Ware in the Doab occurs on the western fringes only. The eastern B-&-R Ware is late and possibly entered the eastern U.P. from Bihar as indicated by the younger C^{14} dates (Fig. 10). In the central U.P., this early B-&-R Ware is virtually absent.

The P.G. Ware people had the iron technology. But a people can carry the know-how and not the ores. It took time to explore the local ores. Hastinapur Pd II* astenec represents an early stage, as the presence of copper arrowhead and lack of iron tools indicate. But by the time they reached Atranjikhera, they had gained access to some local iron ores.

The P.G. Ware people started the real colonisation of the Doab by clearing the forests. But it may be noted that the P.G. Ware is an intrusive trait (just 3-10%of the total ceramics). The Doab was not a wilderness even then. The uniformity of the Copper Hoards shows contacts and intercourse, probably made possible by the riparian communication. The red ware industry in the N.B.P. period in the east (e.g., Sravasti)is the same as that associated with the P.G. Ware in the west (e.g. Hastinapur). It may mean the impinging of an intrusive P.G. Ware over the red ware substratum of the Doab, and the N.B.P. doing the same from the east.

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* In Pd II excepting the arrowhead, the other copper artifacts are of cosmetic use. From the other sites published reports are not available for a comparative study.

Though the colonisation of the Doab was started by the P.G. Ware, yet the urbanisation was made possible only by the arrival of the plentiful iron of Bihar associated with the N.B.P. The first cities of the Doab came up with the advent of N.B.P. in the pre-Mauryan times only. The large scale clearance of forests, ploughing of the hard Doab soil with heavy iron plough-shares and the surplus so produced alone could make the urbanisation feasible. The P.G. Ware settlements were just villages. There were no (and could not be) cities in the Doab till the 5th-6th centuries B.C.

Literary evidence?

The succession of the P.G. Ware and the N.B.P. in the western U.P. is illusory and the gap between the two untenable. The P.G. Ware is a westerly tradition and the N.B.P. an easterly phenomenon, which is clearly pre-Mauryan (Si the). The same red ware types are, as noted above, associated with the P.G. Ware in the west and the N.B.P. in the east, showing their part contemporaneity (Chapter 3). The dating of the two wares too reflects this overlap in point of time. The N.B.P. spread both by diffusion (which was slow) and by trade (which was very fast).

I suggest that N.B.P. spread is associated with the diffusion of iron trade and technology from Bihar. The ferruginous slip of the N.B.P. is quite suggestive of its association with iron. By the time the N.B.P. reached the western U.P. and succeeded the P.G. Ware, the Doab was largely cleared and several cities had sprung up. Let it be emphasised that the N.B.P. and the P.G. Ware are distinctive and independent traditions, though having contacts towards the end. The similarity in fabric is because of the use of the same fine alluvial clay of the Doab. The controlled firing to achieve the grey colour and the geometric motifs of the P.G. Ware and its westerly distribution earn it a distinct identity. So also the characteristic gloss of the N.B.P. imparts it an individuality. Thus a dynamic concept of these cultures explains both the contacts and the individuality, and probably is nearer to the reality.

The Epilogue

I hope the present study justifies the necessity of imparting a technological bias to the archaeological studies. The country now has the modern scientific know-how to help the archaeological studies in a big way. What is needed now is the awareness and the initiative to utilise it. And in doing so the gap between the Two Cultures in India will be further narrowed.

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